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3

NAVAIR 01-45HHA-1T

F-8
Tactical Manual

THIS PUBLICATION IS INCOMPLETE WITHOUT SUPPLEMENTAL F-8 TACTICAL MANUAL NAVAIR 01-45HHA-1T(A)



This publication supersedes NAVAIR 01-45HHA-1T dated 15 September 1968 which should be removed from the files and destroyed.

PREPARED UNDER THE DIRECTION OF
COMMANDER, OPERATIONAL TEST AND EVALUATION FORCE
APPROVED BY THE CHIEF OF NAVAL OPERATIONS

CONFIDENTIAL

section I
AIR-TO-AIR WARFARE

section II
CONVENTIONAL AIR-TO-GROUND WARFARE

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69 635

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NAVAIR 01-45HHA-1T
10 SEPTEMBER 1970

TACTICAL MANUAL INTERIM CHANGE NO. 25

Navy Model F-8 Aircraft

PUBLISHED BY DIRECTION OF THE COMMANDER, NAVAL AIR SYSTEMS COMMAND

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The above applies only to Classified documents.

Of paramount interest to pilots. To be read by all pilots operating these aircraft.

1. CANCELLATION: None (U)

2. (U) PURPOSE: To authorize use of the DESTRUCTOR MK-36 MODS 2 and 3 on F-8 Aircraft.

3. (C) ACTION: Make the following modifications to the F-8 TACTICAL Manual, NAVAIR 01-45HHA-1T, dtd 1 July 1969:

   A. On page 2-7, lines number 7 through 11; in the Store column add "MK-36 DESTRUCTOR Conical Fin," and in the Remarks column add "SEE NOTE 11."

   B. On page 2-8, lines number 1 through 4, 6, 7, 9, and 10, in the Remarks column add "SEE NOTE 11."

   C. On page 2-18, add the following as Note 11:

   "11. The MK-36 MODS 2 and 3 DESTRUCTOR have improved arming and firing mechanisms incorporated which allow unretarded delivery within the following limits: The impact velocity must not exceed 900 feet per second, the impact angle must be at least 30 degrees, and only land targets may be used. Ballistic characteristics of the MK-82 bomb apply. When used in the retarded mode, the aircraft limitations of the MK-82 Snakeye Retarded bomb apply. The MK-36 MOD 0 and MOD 1 versions are still restricted to retarded deliveries only. Unretarded impact limitations will be satisfied if the weapons are released between the maximum and minimum altitudes specified for the airspeed and attitude combinations listed in Figures 1 and 2 (for Conical and Snakeye Fins respectively) of Interim Change 25.

   NOTE: These Figures do not necessarily provide for dive recovery or fuse arming time. They are designed to satisfy only impact criteria based on an ejection velocity of 5.6 feet per second."

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D. Retain this Interim Change at the front of the manual until the above modifications have been incorporated in a manual change or revision.

RELEASE CONDITIONS FOR UNRETARDED
DELIVERY OF DESTRUCTORS MK 36 MOD 2 AND MOD 3
WITH CONICAL FINS

Release Speed (KTAS)		Release Altitudes (ft) for Release Angles of												
		-60	-50	-40	-30	-20	-10	0	+10	+20	+30	+40	+50	+60
200	min	200	200	200	200	300	500	600	550	350	200	200	200	200
	max	12050	12075	12100	12125	12175	12200	12200	12225	12200	12175	12150	12125	12100
250	min	200	200	200	200	500	800	900	800	500	200	200	200	200
	max	11050	11075	11125	11175	11250	11300	11325	11350	11325	11300	11250	11200	11150
300	min	200	200	200	200	700	1200	1300	1200	700	200	200	200	200
	max	9800	9850	9925	10000	10100	10175	10250	10300	10300	10250	10175	10100	10025
350	min	200	200	200	200	1000	1625	1750	1500	900	200	200	200	200
	max	8275	8350	8450	8575	8725	8850	8975	9075	9100	9050	8950	8825	8725
400	min	200	200	200	200	1350	2000	2325	2000	1150	200	200	200	200
	max	6500	6575	6700	6850	7050	7275	7500	7675	7725	7700	7575	7400	7250
450	min	200	200	200	200	1500	2500	2850	2500	1350	200	200	200	200
	max	4375	4475	4600	4775	5050	5375	5750	6050	6225	6225	6075	5850	5625
500	min	200	200	200	200	2000	3000	3500	2850	1500	200	200	200	200
	max	1900	1950	2050	2200	2475	3000	3600	4200	4550	4625	4450	4175	3875
550	min	—	—	—	—	—	—	—	—	1750	200	200	200	200
	max	—	—	—	—	—	—	—	—	2675	2900	2750	2425	2025
600	min	—	—	—	—	—	—	—	—	—	200	200	200	—
	max	—	—	—	—	—	—	—	—	—	1150	1025	625	—

NOTES: (1) Negative release angles indicate release angles below horizontal (dive); positive angles above horizontal.
(2) Altitudes listed may not provide dive recovery or fuse arming time.
(3) Altitude values are based on an ejection velocity of 5.6 feet per second.

Figure 1

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RELEASE CONDITIONS FOR UNRETARDED
DELIVERY OF DESTRUCTORS MK 36 MOD 2 AND MOD 3
WITH SNAKEYE MK 15 FINS - CLOSED

Release Speed (KTAS)		Release Altitudes (ft) for Release Angles of												
		-60	-50	-40	-30	-20	-10	0	+10	+20	+30	+40	+50	+60
200	min	200	200	200	200	300	500	575	525	250	200	200	200	200
	max	14100	14175	14250	14325	14400	14425	14500	14500	14475	14425	14350	14275	14200
250	min	200	200	200	200	450	800	875	775	475	200	200	200	200
	max	13100	13200	13325	13450	13600	13700	13775	13800	13775	13700	13575	13450	13325
300	min	200	200	200	200	700	1100	1225	1050	600	200	200	200	200
	max	11825	11975	12175	12375	12600	12775	12925	12975	12950	12850	12675	12475	12300
350	min	200	200	200	200	900	1500	1600	1375	750	200	200	200	200
	max	10250	10450	10725	11025	11350	11675	11900	12025	12025	11875	11650	11375	11125
400	min	200	200	200	200	1175	1875	2025	1675	875	200	200	200	200
	max	8300	8550	8900	9350	9850	10325	10725	10975	11000	10850	10550	10175	9825
450	min	200	200	200	200	1500	2375	2450	2000	1000	200	200	200	200
	max	5875	6150	6575	7175	7925	8700	9375	9800	9900	9725	9375	8900	8425
500	min	200	200	200	200	1750	2850	2925	2325	1100	200	200	200	200
	max	2725	2975	3375	4100	5250	6600	7750	8475	8750	8575	8125	7550	6975
550	min	—	—	—	—	—	—	3400	2650	1175	200	200	200	200
	max	—	—	—	—	—	—	5650	7025	7500	7400	6875	6175	5450
600	min	—	—	—	—	—	—	—	2950	1225	200	200	200	200
	max	—	—	—	—	—	—	—	5300	6225	6175	5600	4750	3900

NOTES: (1) Negative release angles indicate release angles below horizontal (dive); positive angles above horizontal.
(2) Altitudes listed may not provide dive recovery or fuse arming time.
(3) Altitude values are based on an ejection velocity of 5.6 feet per second.

Figure 2

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F-8
Tactical Manual (U)

THIS PUBLICATION IS INCOMPLETE WITHOUT SUPPLEMENTAL F-8 TACTICAL MANUAL NAVAIR 01-45HHA-1T(A)



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PREPARED UNDER THE DIRECTION OF
COMMANDER, OPERATIONAL TEST AND EVALUATION FORCE
APPROVED BY THE CHIEF OF NAVAL OPERATIONS

section I
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1 July 1969
Changed 15 June 1970

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DEPARTMENT OF THE NAVY
OFFICE OF THE CHIEF OF NAVAL OPERATIONS
WASHINGTON, D.C. -20350

1 July 1969

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1. The F-8 TACTICAL MANUAL (U) is a Confidential publication and a supplement to NWP 41, NAVAL AIR OPERATIONS. It is effective upon receipt and supersedes the previous edition, dated 15 September 1968, which shall be destroyed in accordance with the Security Manual for Classified Information.

2. Tactical manuals provide the latest and most accurate tactical information to aircrews and tactical commands. These manuals are designed to promote the development of efficient and sound tactical doctrine, and to eliminate the need for promulgation of doctrine by individual squadrons. These manuals are compiled using Fleet inputs and are kept current to achieve maximum combat readiness. To provide the latest data, Navy and Marine Fleet/Type/Air Wing/Squadron Commanders are directed to review these procedures on a continuing basis, and submit recommended modifications as outlined under "Change Recommendations."

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R. E. RIERA
Rear Admiral, USN
Assistant Deputy Chief of Naval Operations
(Fleet Operations and Readiness)

INTERIM CHANGE SUMMARY

THE FOLLOWING CHANGES HAVE BEEN CANCELED OR PREVIOUSLY INCORPORATED IN THIS MANUAL	
CHANGE NUMBER(S)	REMARKS
1 through 18	

THE FOLLOWING CHANGES HAVE BEEN INCORPORATED IN THIS CHANGE/REVISION		
CHANGE NUMBER	CHANGE DATE	PURPOSE
19	5 Sep 69	Adds limitation for retarded Mk 82 Snakeye bombs
20	3 Nov 69	Authorizes carriage/release of Mk 76 from MER/TER
21	25 Feb 70	Clears use of Mk 89 on MER/TER; modifies existing clearance for Mk 86/87
22	10 Apr 70	Restricts use of M-1 bomb fuze extensions from carrier operations or field arrestments

INTERIM CHANGES OUTSTANDING – TO BE MAINTAINED BY CUSTODIAN OF THIS MANUAL			
CHANGE NUMBER AND DATE	DATE CHANGE MADE	PAGES AFFECTED	PURPOSE
24 6-30-70	13 OCT 1970	58 E + F	
#25 10 SEPT 70	23 MAR 71	2-7, 2-8, 2-18	AUTH USE OF MK36 DESTEX FUZE

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Yankee Team Tactics, Annex Tango

NAVAIR 01-45HH-75 Series

GLOSSARY OF TERMS AND ABBREVIATIONS

AAA	Anti-Aircraft Artillery
AAM	Air-to-Air Missile
AAW	Anti-Air Warfare
A/B	Afterburner
ACM	Air Combat Maneuvering
ADL	Armament Datum Line. Establishes reference for armament and fire control components. −1° from FRL
AFC	Automatic Frequency Control
AGL	Above Ground Level (height)
AH BAR	Artificial Horizon Bar
AI	Aircraft Interception. Applies to radars designed for fighters
AIC	Airborne Intercept Controller
AIM	Air launched, intercept-aerial guided missile
ALIGNMENT	(1) The process of adjusting the tuned circuits of a radar receiver to a predesignated natural frequency. (2) The process of adjusting two or more components of a system so that their functions are properly synchronized; i.e. antenna orientation, and a B-scope sweep
ALT	Altitude
ALTITUDE LINE	A heavy band of clutter produced by radar energy reflection from the earth's surface
ANGELS	Altitude in thousands of feet
ANGLE OF ATTACK	The angle between the FRL and airplane flight path
ARO	Automatic ranging only
ASM	Air-to-Surface Missile
ATTENUATION	(wave) The decrease in amplitude with distance in the direction of wave propagation
B-SCAN	Type of presentation in which signal appears as a bright spot with azimuth angle as the horizontal coordinate and elevation as the vertical coordinate
BARCAP	Barrier Combat Air Patrol
BARREL WHIP	Movement of the barrel in an eliptical orbit during gun firing
BEAM WIDTH	The width (angle between half-power points) in degrees of the effective radiation from an antenna
BLIP or PIP	A target echo signal return displayed on radar scope
BOGEY	Unknown Air Target
BULLET BOUNCE	Projectile movement away from the fuselage due to fuselage airflow
BULLET DENSITY	Number of rounds per unit area, per unit time. Varies inversely proportional to square of the range. (i.e., double range, density 1/4)
BUSTER	Full Military Power
C-SCAN	Type of presentation in which the signal appears as a bright spot with azimuth angle as the horizontal coordinate and elevation as the vertical coordinate
CAP	Combat Air Patrol
CAS	Close Air Support
CBU	Cluster Bomb Unit
CCA	Carrier Controlled Approach
CCI	Carrier Controlled Intercept
CIC	Combat Information Center
CL_{max}	Maximum Coefficient of Lift
CON	Contrail
CONICAL SCAN	A type of scan in which the tilt angle is fixed so that the axis of the RF beam is caused to nutate. The principle is used in angle tracking application.
CONNING	Making Contrails
CRT	Combat Rated Thrust
DLI	Deck Launched Interceptor
DUCTING	Bending of radar waves by changes in atmospheric water vapor content and temperature
ECCM	Electronic Counter-Countermeasures
ECM	Electronic Countermeasures
ELEVATION	The angle of the target above or below the radar set
EMCON	Electromagnetic Radiation Control
ER	Ejection Rack

GLOSSARY OF TERMS AND ABBREVIATIONS (Continued)

EW	Early Warning
FP	Flight path: flight line taken by aircraft in relation to surrounding air mass
FPM	Feet Per Minute
FRL	Fuselage Reference Line, or the water line. A longitudinal reference line of the airplane
FTC	Fast Time Constant
g	Gravitational Force
GATE	Combat rated thrust
GBL	Gun Bore Line: line drawn through center of gun bore projected to infinity
GCI	Ground Controlled Intercept
GD	Gravity Drop: gravity effect upon a projectile during its time of flight
HOJ	Home-On-Jam
IAS	Indicated Airspeed
ID	Identification
I-F	Intermediate Frequency
IFF	Identification Friend or Foe
IMN	Indicated Mach Number
IP	Initial reference point in the vicinity of the target
IR	Infrared
IRCM	Infrared Countermeasures
JAMMING	Intentional interference with the operation of radars
JINKING	Passive defense maneuver
JUDY	Call made when pilot takes control of the intercept
KCAS	Knots Calibrated Airspeed
KIAS	Knots Indicated Airspeed
KTAS	Knots True Airspeed
LAU	Launcher Unit
LBA	Limits of Basic Aircraft
LDGP	Low Drag General Purpose (Bomb)
LOS	Line of Sight. Imaginary line from the eye to the aiming point through the optical sight
MACH	Measurement of speed with relation to the speed of sound
MAGNETRON	A transmitting tube which produces the main pulse of energy. The flow of electrons is controlled by the applied magnetic field
MAIN BANG	That portion of the transmitted pulse that leaks into a radar receiver
MAX	Maximum
MBR	Multiple Bomb Rack
MEGACYCLE	One million cycles
MER	Multiple Ejector Rack
MICROSECOND	One millionth of a second
MICROWAVES	Radio waves the length of which is approximately less than one meter
MIL	Milliradian is a unit of angular measurement which subtends one foot at 1,000 feet. One degree equals 17.45 mils.
MK	Mark. Navy designation for model
MOD	Navy designation for modification
MODULATOR	The part of the radar set that controls the application of plate voltage to the transmitter
MPI	Mean Point of Impact
MRT	Military Rated Thrust
MSL	Mean Sea Level
NM	Nautical Miles
OCE	Officer Conducting the Exercise
OSL	Zero Sight Line, parallel to ADL (fixed pipper)
PMBR	Practice Multiple Bomb Rack
PPH	Pounds per hour
PPI	Plan Position Indicator
PRF	Pulse Repetition Frequency

GLOSSARY OF TERMS AND ABBREVIATIONS (Continued)

PRT	Pulse repetition time
PULSE WIDTH	The time duration of a pulse
R_o	Missile Aerodynamic Range
RAD CAP	Radar Picket Combat Air Patrol
RBL	Radar Boresight Line
RCVR	Receiver
RELEASE HEIGHT	Release Altitude AGL
RF	Radio Frequency
R_{max}	Maximum Firing Range
R_{min}	Minimum Firing Range
SAM	Surface-to-Air Missile
SEA RETURN	Signals reflected back from the sea
SEARCH LIGHTING	Projecting the radar beam continuously at any given object or target, instead of illuminating it once during each scan period
SECTOR SCAN	Motion of an antenna back and forth through a limited angle
SIDE LOBE	A portion of the beam of a radar antenna other than the main lobe and usually much smaller. Antenna dish spill over
SIF	Selective Identification Friend or Foe
SIGHT ANGLE	The angle between OSL and the line of sight
SIGHT PARALLAX	Slight error generated by the distance between OSL and GBL (41.5 inches)
SIGNAL-TO-NOISE-RATIO	The ratio, at any part of the circuit, of signal power to total circuit noise power
SLANT RANGE	The distance between release point and the target
STAE	Second-Time-Around Echo
SW	Sidewinder
TARCAP	Target Combat Air Patrol
TARGET	Any object producing a radar echo
TCA	Track Crossing Angle
TER	Triple Ejector Rack
TILT	The angle the antenna forms with the horizon
TRAJECTORY DROP	GD expressed in MILS from OSL
TOF	Time of Fall
TS	Trajectory Shift: projectile's angular deviation from the GBL into relative wind toward FP. TS also referred to as Velocity Jump
V_c	Closing Velocity
V_f	Velocity of Fighter
VID	Visual Identification
VIDEO	The intelligence of a radar echo
V_{max}	Maximum Velocity
V_{min}	Minimum Velocity
V_t	Velocity of the Target
WAVE-GUIDE	A hollow pipe, usually of rectangular cross section used to transmit RF energy.

INTRODUCTION

SCOPE

The F-8 Tactical Manual, prepared under the direction of Commander, Operational Test and Evaluation Force and approved by the Chief of Naval Operations, contains the latest information regarding the tactical employment of the F-8A, H, J, K, and L aircraft and its various combat missions. Information contained in this manual has been derived from many sources to provide one main source for procedures, techniques, and data to enable the pilot to most effectively employ the aircraft and its weapons system in combat. The NATOPS Flight Manual standardizes ground and flight training procedures and contains the information to thoroughly acquaint the pilot with the aircraft. Information in this manual is primarily oriented to Tactical Employment of the aircraft which presupposes a thorough knowledge of the NATOPS Flight Manual. A description of the Aircraft Tactical Manual program is contained in OPNAVINST 3510.12 (series).

ARRANGEMENT

The Tactical Manual consists of the Confidential Manual and a Secret Supplement. Each has the same format. There are five sections.

Section I. **AIR-TO-AIR WARFARE,** is subdivided into seven parts:

Part I describes the aircraft and its characteristics, the tactics and techniques every fighter pilot should be aware of before engaging the enemy in air-to-air warfare. It includes items of consideration for engagement during a tactical situation and applies energy maneuverability to a hypothetical tactical condition.

Part 2 describes briefing requirements and procedures for conducting the various described combat air patrols.

Part 3 describes escort tactics and the various types of escort missions.

Part 4 describes basic radar fundamentals, the operating parameters of F-8 aircraft radar, and the tactics employed in performing intercepts. A description and illustration are included on use of the B-scope for radar mapping.

Part 5 describes the countermeasures effects and counter-countermeasures procedures for effecting the intercepts described in Part 4.

Part 6 discusses AIM-9 missiles launch envelopes with emphasis on the dynamic effects of maneuvering targets.

Part 7 describes procedures for missile and gun firing under controlled conditions on towed targets.

Section II, **CONVENTIONAL AIR-TO-GROUND WARFARE,** is subdivided into four parts:

Part 1 lists and describes those items that should be considered in planning a tactical mission. Also included are the limitation tables and performance charts necessary to plan the various types of tactical missions.

Part 2 lists and describes the various attack missions that pilots may be assigned for accomplishment.

Part 3 describes the types of maneuvers and delivery techniques to be used in placing the F-8 weaponry on the proper target.

Part 4 contains weapons system harmonization procedures and a detailed description and illustration of individual weapons used by the F-8 in both its air-to-air and air-to-ground missions.

Section III, **NUCLEAR AIR-TO-GROUND WARFARE,** is not applicable to the F-8.

Section IV, **ENEMY GROUND DEFENSES AND FRIENDLY COUNTERMEASURES,** is subdivided into 6 parts all of which are in the (Secret) Supplemental F-8 Tactical Manual (U), NAVAIR 01-45HHA-1T(A).

Section V, **AIRCRAFT EMPLOYMENT,** is subdivided into two parts:

Part 1 lists and describes the types of air-to-air missions the F-8 is expected to fly.

Part 2 describes the employment, external armament limitations and carrier limitations for air-to-ground weapons delivery.

HOW TO OBTAIN COPIES

ADDITIONAL COPIES

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To receive future changes and revisions to this manual automatically, a unit must be established on the automatic distribution list maintained by the Naval Air Technical Services Facility (NAVAIRTECHSERVFAC). To be established on the list or to change distribution requirements, a unit must submit NAVWEPS Form 5605/2 to NAVAIRTECHSERVFAC, 700 Robbins Ave., Philadelphia, Pa. 19111, listing this manual and all other NAVAIR publications required. For additional instructions, refer to BUWEPINST 5605.4 series and NAVSUP publication 2002.

INTRODUCTION (Continued)

POCKET GUIDE

The F-8 Tactical Manual Pocket Guide (NAVAIR 01-45HHA-1T(B)) is not distributed automatically with this manual and therefore must be ordered as a separate publication using the above mentioned procedures for Tactical Manuals. The Pocket Guide is printed on cardboard stock and is designed to be fastened to the pilot's knee pad. The Pocket Guide contains the essential data required to provide inflight flexibility.

TACTICAL MANUAL BALLISTICS TABLES

The Tactical Manual Ballistics Tables contain additional information which is common to all tactical aircraft, such as trajectory drop, down range travel, etc, for various weapons. This publication is not distributed automatically with this manual and, therefore must be ordered as a separate publication in the same manner as the pocket guide.

UPDATING THE MANUAL

To ensure that the manual contains the latest procedures and information, a review conference is held periodically, as necessary.

YOUR RESPONSIBILITY

The Tactical Manual is kept current through an active manual change program. If you find anything you don't like about the manual, if you have information you'd like to pass along to others, or if you find an error in this manual, submit a change recommendation to the Model Manager at once.

CHANGE RECOMMENDATIONS

Recommended changes to this manual may be submitted by anyone in accordance with OPNAVINST 3510.12 (series). Change recommendations of an URGENT nature should be submitted directly to the originators Type Commander by priority message. Submit routine change recommendations to the model manager on OPNAV Form 3500-22 (see copy this section). Address routine changes to: Air Test and Evaluation Squadron Four, U.S. Naval Air Station, Point Mugu, California, 93041.

INTERIM CHANGE SUMMARY

The interim change summary is provided for the purpose of maintaining a complete record of all interim changes issued to the manual. Each time the manual is changed or revised, the interim change summary will be formally up-dated to indicate disposition and/or incorporation of previously issued interim changes. When a regular change or revision is received, the interim change summary should be checked to ascertain that all outstanding interim changes have been formally incorporated or canceled. Those changes that were not incorporated should be noted as applicable.

CHANGE SYMBOLS

Revised text is indicated by a black vertical line in either margin of the page, like the one printed next to this paragraph. The change symbol shows where there has been a change. The change might be material added or information restated.

WARNINGS, CAUTIONS AND NOTES

From time to time "Warnings," "Cautions," or "Notes" are inserted in the running text. This is to call attention to some phasy of aircraft operation that is especially important, as follows:

WARNING

Operating procedures, practices, etc, which may result in personnel injury or loss of life if not carefully followed.

CAUTION

Operating procedures, practices, etc, which if not strictly observed may result in damage to equipment.

Note

An operating procedure, condition, etc, which it is essential to emphasize.

INTRODUCTION (Continued)

WORDING

The concept of word usage and intended meaning which has been adhered to in preparing this manual is as follows:

"Shall" has been used only when application of a procedure is mandatory.

"Should" has been used only when application of a procedure is recommended.

"May" and "need not" have been used only when application of a procedure is optional.

"Will" has been used only to indicate futurity, never to indicate any degree of requirement for application of a procedure.

SECURITY CLASSIFICATION

The classified material in this manual is in Downgrading and Declassification Groups 3 and 4. Pages which have been prepared under contracts dated before 1 July 1967 are marked at top and bottom of the pages only. The pages within Part 1, Section I are marked in the same manner, because all text collectively is classified CONFIDENTIAL, Group 4.

The material in this manual which has been prepared under contracts dated 1 July 1967 or later is identified as follows:

a. Downgrading and Declassification Group 3 material will be identified by (C) at the beginning of each paragraph.

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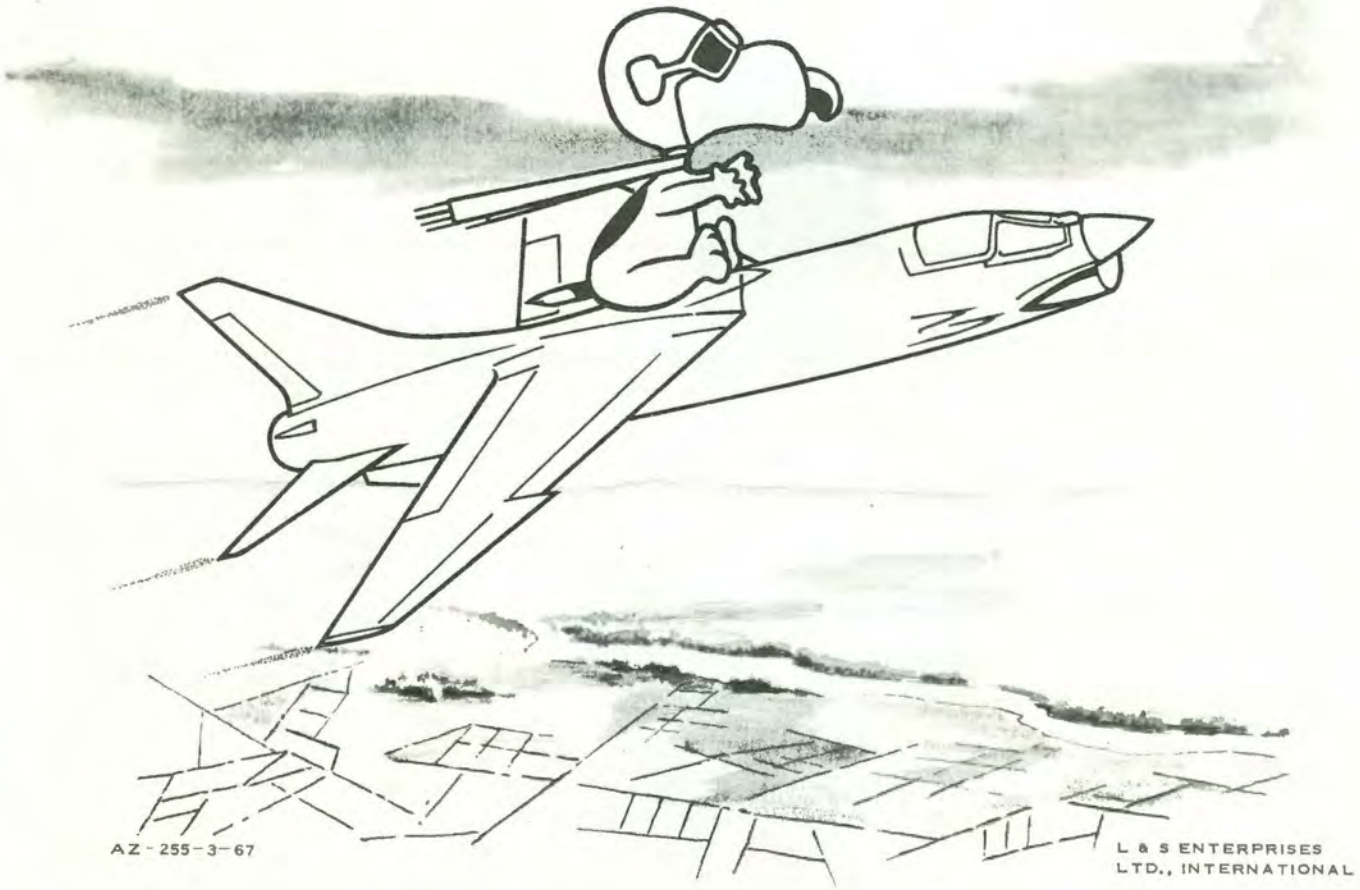
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"The fighter pilots have to rove in the area allotted to them in any way they like, and when they spot an enemy they attack and shoot him down. . . . anything else is rubbish."

Von Richthofen



AZ-255-3-67

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section I
air-to-air warfare

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PART 1 — AIR COMBAT MANEUVERING

"No study is possible on the battlefield; one does there simply what one can in order to apply what one knows. Therefore, in order to do even a little, one has already to know a great deal and know it well."

Foch

INTRODUCTION

Air-to-air combat is considered the ultimate in airmanship by all fighter pilots. There is no greater test of aggressiveness and skill than to engage and destroy an enemy flying a high performance aircraft.

A well-coordinated, carefully planned aerial attack training program is the key to combat effectiveness. Chances of success in aerial combat will be increased by a thorough knowledge of your weapon system and that of your enemy. In achieving the advantage over an enemy, you must maneuver three-dimensionally from point A to B to C with almost psychic awareness of airspeed, altitude, g, angle of attack, and the aircraft's performance limits. Ground training cannot replace in-flight training but is a valuable supplement to it. Increased understanding of maneuvering relationships and basic control techniques will not only increase your chances of success in combat but will also reduce aircraft losses in routine flight operations.

Basic considerations which must prevail in the fighter versus fighter environment include the following: Always fly prepared for a fight. The use of full cockpit heat plus defog may be required to preclude fogging following descents from higher altitudes. Keep seat and shoulder harness adjusted so that maximum visibility can be maintained. Have armament switches set up as needed. During each attack on training flights, at least touch the switches which would require adjustment. When closing from missile range into gun range, be prepared to switch to guns to effectively climax the engagement with a kill.

A pilot must understand the operating envelope and characteristics of his weapons system. Having learned the envelope parameters, he must determine how best to employ his weapon system against any enemy.

All offensive tactical maneuvers discussed in this manual can be utilized for either Sidewinder or 20mm attacks. Arriving in a position to execute a 20mm attack will, in almost all cases, result in passing through the AIM-9D envelope. Therefore AIM-9D should be considered the primary weapon unless the tactical situation dictates otherwise. This is not necessarily true for AIM-9B.

F-8 CHARACTERISTICS

FAVORABLE

The F-8 has excellent subsonic and supersonic maneuvering characteristics, good climb and acceleration performance and a long range capability. Some favorable yaw (in the direction of turn) exists during roll at 1.3 IMN and above, but is dampened out by the aileron-rudder interconnect. Radar and AIM-9C missile capability allow use of the aircraft as an all-weather fighter.

UNFAVORABLE

Adverse yaw exists in subsonic flight during roll and is further amplified by the aileron-rudder interconnect. This can be countered by the use of rudder. The F-8 is not area ruled for missiles or external stores. Addition of these adds extra pressure (or wave) drag in combat configurations which results in decreased performance. The aircraft has violent accelerated stall and spin characteristics and does not maneuver well in slow flight. Engaging and disengaging the afterburner leaves a white puff of smoke in the air which can be seen for several miles. By modern standards, the F-8 has a poor fire control system. Required tracking time for a gun lead situation is two seconds, sight tolerances are several mils, and gun buffet dispersion is a "scatter gun" type.

CLIMB AND CRUISE

The NATOPS Flight Manual, the REST computer and the cruise control section in this manual give the correct climb and cruise figures to obtain optimum altitude and range. Maximum excess power occurs at 480 KTAS at MRT and at 0.92 IMN at CRT. The climb schedule should be used when changing altitude. Speeds other than these climb schedules (MRT and CRT) cause a decrease in thrust to drag ratio and consequently a decrease in climb performance. The result is an increase in time to climb and fuel required to reach a given altitude. However, at 40,000 feet and above, Mach numbers as high as 0.98 will be required to hold a reasonable rate of climb. When patrolling in a combat area, speed significantly in excess of max range speed will be required — the increase in fuel consumption being accepted for sake of instantaneous maneuverability.

For cruising only, cruise droop should be extended at subsonic speeds of 350 KIAS and below. Retraction of the droop when transonic will expedite acceleration to supersonic speeds. When supersonic the F8 performs superbly with the droop in. At altitude, in the 1.0 to 1.2 IMN range, cruise droop should be extended for tactical maneuvering. Approximately 2 to 5 seconds are required for the droop to extend or retract.

ACCELERATION

Due to the transonic drag rise, level acceleration through the 0.95 to 1.15 IMN area will be slow. It is generally worth the time and fuel to climb to 45,000–50,000 feet, retract the cruise droop approaching Mach 1.0 and ease over at 0.5g to establish a 4000–5000 fpm nose-down dive. At about 35,000 to 38,000 feet, level off and accelerate to V_{max} (about 5 min). A 2g, 30-degree nose-up pitch from V_{max} at 40,000 feet will put the F-8 into the missile envelope for almost all high flying aircraft.

TACTICAL MANEUVERING PERFORMANCE

MANEUVERING PERFORMANCE

Tactical maneuvering performance is determined by g availability, the aircraft operating strength limit, and the power available.

G Availability

Available g is a combination of the maximum lift coefficient, airspeed, and the wing loading. Available g can be increased by increasing airspeed, decreasing weight (fuel or external stores), or increasing CL_{max} (extending droop). Tactically, the droop should be extended for all maneuvering up to 550 KIAS.

Note

Above 400 KIAS 6.4g is available with the droop extended or retracted. Approximately 30 knots in excess of the airspeed indicated on the V-n diagram will be necessary to attain limit g. This is due to speed bleed-off as g is applied.

Operating Strength Limit

In most high g maneuvering situations below 400 KIAS, subsonic, the aircraft will stall before reaching structural limit. Above 400 KIAS or 1.1 IMN it is possible to attain g in excess of the structural limit (6.4g). Under high g conditions, it is possible to decelerate through 1.0 IMN and encounter g overshoot resulting in a stall, spin, structural damage, or all three. Due to wing flexing under high g loads, it is possible to damage the cruise droop (when extended) under conditions that do no damage to the wing. Consequently, the droop should be retracted whenever the possibility exists that 500 KIAS will be exceeded and a limit of 550 KIAS is not acceptable due to the tactical situation and/or the aircraft will be operated in the 500 KIAS, 6.4g regime for any length of time.

Power Limit

Available engine thrust multiplied by the airspeed (Power equals Thrust times Airspeed) determines the ability of the aircraft to turn while maintaining a constant altitude. The limiting condition is met when total drag, consisting of airframe drag and drag induced by the increased load factor, equals the power available. Thrust is nearly constant with change in airspeed while power increases almost linearly with an increase in airspeed. Maximum excess power occurs at a relatively high airspeed where airframe drag starts its rapid increase (480 KTAS in MRT and 0.92 IMN in CRT, the same as when cruising). Ideally, the F-8 should be continuously operated at these speeds during an engagement since they represent the area of maximum sustained energy and therefore sustained maneuverability. As altitude increases, engine thrust is reduced. Assuming an MRT thrust output of 10,000 pounds at sea level, the following table presents thrust available at various altitudes.

THRUST VS ALTITUDE

Altitude (Feet)	*Thrust (Pounds)*
Sea Level	10,000
5,000	8,800
10,000	7,850
20,000	6,040
35,000	3,920
40,000	3,150
50,000	1,800

Afterburner thrust also decreases at higher altitudes but not as severely as the basic engine thrust. Use of afterburner at 35,000 feet will double the thrust output of the engine, and is most effective at high speeds. It should be used during nose-low, low g conditions for acceleration to maintain tactical advantage, and when V_{max} is necessary. It should not be used in high g, low speed conditions unless absolutely necessary, nor for the initial attack if the fighter is not conning and there is a probability of completing the attack undetected. The afterburner should be exercised to ascertain light-off reliability. Due to the white burner puff, this should be done in friendly territory.

Subsonic Maneuvering Envelope

The general subsonic maneuvering envelope is defined by minimum and maximum speeds for various altitudes. Airspeeds below these minimums will cost fuel, altitude, and time to regain a maneuvering potential. The maximum speeds shown are where maximum g is available or where parasite drag starts to rise. If airspeed is being increased only to increase g available, the turn back into the enemy should be started when the drag rise area is reached or where maximum structural g is available. Airspeeds above these values will result in increased fuel consumption and larger turn radii. There will be times when airspeeds greatly in excess of the maximums shown will be necessary to gain separation or maintain a high energy level.

SUBSONIC MANEUVERING ENVELOPE

Altitude (Feet)	*MIN IAS/IMN*	*MAX IAS/IMN*
Sea Level	185	450/0.68
15,000	200/0.4	450/0.87
25,000	215/0.52	407/0.95
35,000	235/0.7	330/0.95
45,000	250/0.82	265/0.95

Supersonic Maneuvering

The Crusader turns well supersonically. For example, at 35,000 feet at 0.90 IMN, 2½g are about all that can be pulled, resulting in a horizontal turn radius of approximately 22,000 feet. At 1.1 IMN however, at the same altitude, 3½g can be pulled which also results in a turn radius of 22,000 feet. The subsonic turn described is not a maximum performance, minimum radius turn, but is used to compare the supersonic advantages. Enough total energy must remain upon completion of the first turn to use the separation or time gained to effectively engage the enemy. In a 1.1 IMN head-on pass at 45,000 feet, the first turn for engagement is going to result in an airspeed loss if the turn is made nose high (decreased radius/increased rate vertical turn), with a concurrent loss in kinetic energy and maneuvering potential. If the turn is made nose low, altitude and turn radius are sacrificed but Mach number and maneuvering potential are maintained. The tactical situation will determine which turn to use.

To determine optimum rate of turn and radius of turn when maneuvering at a constant airspeed, altitude and bank angle refer to figure 1–1.

ENGAGEMENT CONSIDERATIONS

Air supremacy must be maintained in the parcel of airspace needed for support of tactical ground activity. As the enemy's ability to saturate an airspace improves, the ability to destroy him with economy of action must also improve. Fighter tactics must be thoroughly understood to effectively accomplish each mission within the available combat time as limited by fuel and ammunition.

The decision of whether or not to engage the enemy must be made as early as possible. An intelligent decision cannot be made without a knowledge of fuel state, armament available, enemy aircraft characteristics and the tactical situation.

FUEL

Always be aware of the on-station time remaining. Know how much CRT operation can be used and still permit a safe return to the ship or base with the required minimum fuel. Keep a running count (How-goes-it) of total fuel required to complete the mission. Tactical supersonic fuel usage can and must be planned for. At 1.0 IMN in afterburner at 40,000 feet the total fuel flow is approximately 17,000 PPH, but at 1.8 IMN at 40,000 feet, total fuel flow is approximately 39,000 PPH. See figure 1–2.

ARMAMENT

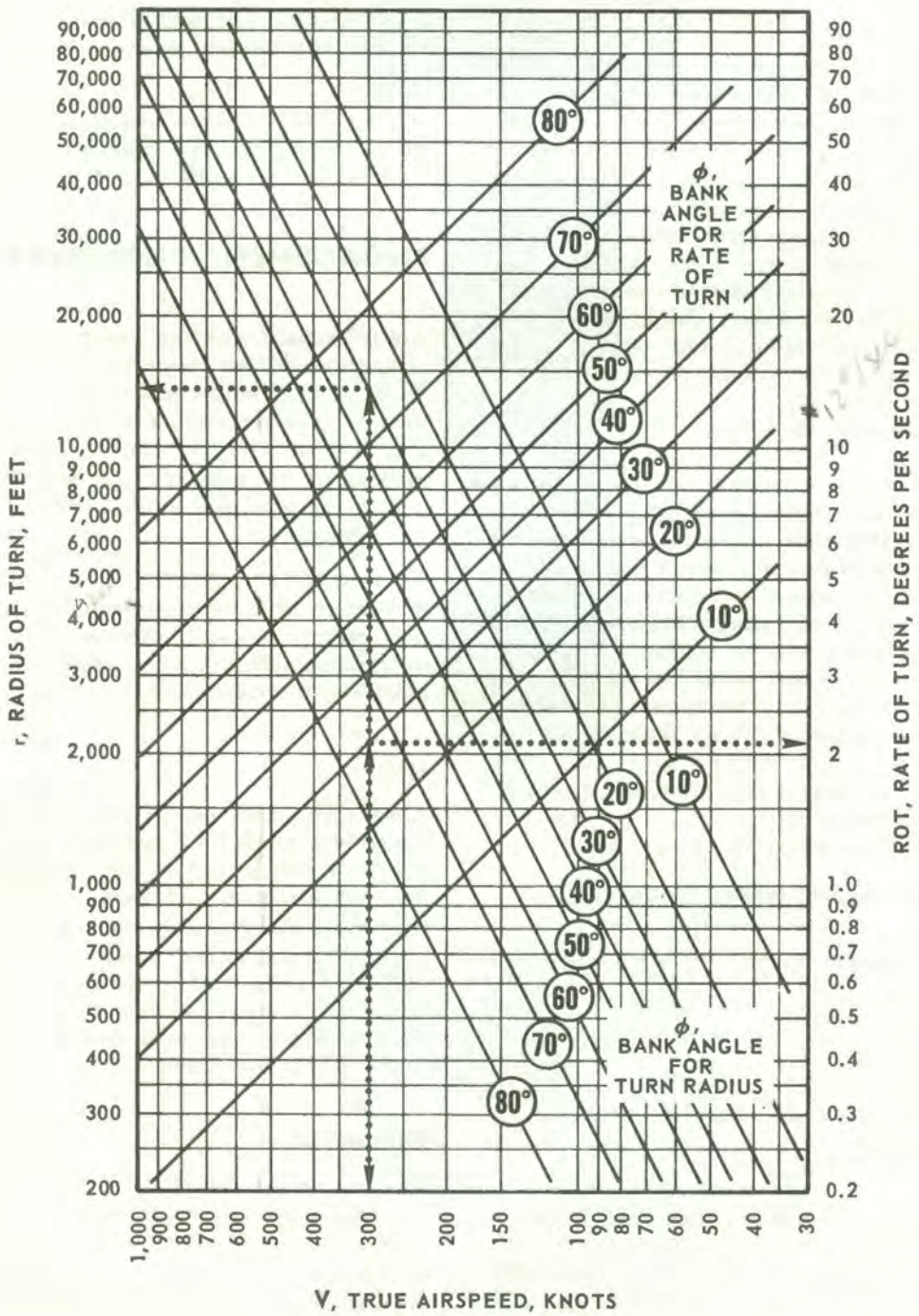
The F-8 has the capability to carry four Sidewinders; however, a more feasible external load is two Sidewinders on single pylons for fighter air-to-air combat. This results in considerably increased performance characteristics. The four 20-millimeter cannons provide an alternate weapon in the event the Sidewinders are expended or a close-in weapon is required.

General Turning Performance Constant Altitude, Steady Turn



EXAMPLE:

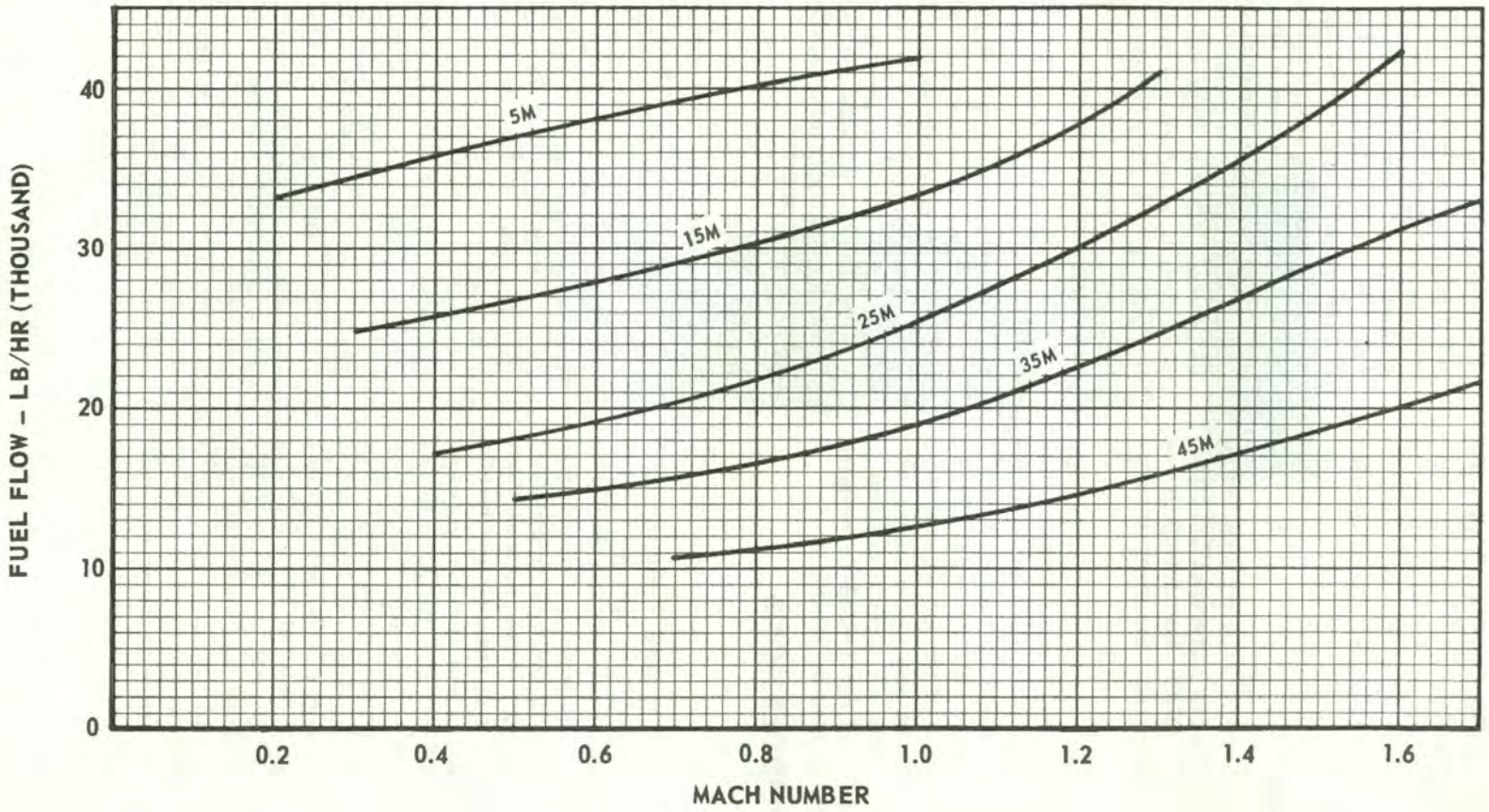
V = 300 KNOTS
ϕ = 30°
r = 13,800 FT
ROT = 2.10°/ SEC



AZ-235-2-67

Figure 1-1

CRT Fuel Flow (J57-P-20, -20A)



AZ-181-5-68

Figure 1–2

ENEMY AIRCRAFT CHARACTERISTICS

Knowledge of the enemy aircraft is essential. Know its particular characteristics: armament, speed, and maneuvering performance. If a MIG-17C is met head on at 35,000 feet and a slow-speed fight develops, the F-8 is at a serious tactical disadvantage. If a section of MIG-21's is engaged at 52,000 feet, the F-8 is again out of its best operating envelope. Plan ahead. Do not let the enemy win the fight because of a poor decision prior to the engagement.

TACTICAL SITUATIONS

There are three advantages that in some cases can be established prior to engagement. These are POSITION, SPEED, and ALTITUDE. With these advantages, it will be possible to maneuver into the firing envelope of your weapons.

Knowledge that the enemy is in the area is of primary importance. Whether you are GCI controlled, find him on the radar, or hold him visually, start planning for the position, speed and altitude advantage immediately. Do not give the enemy an even break. Use the sun to advantage. Attack out of the sun when there is a choice, as firing into the sun may render a heat seeking missile ineffective. The six o'clock position is optimum for the delivery of the Crusader's weapons, so get there undetected as soon as possible.

TACTICAL CONSIDERATIONS

VISIBILITY

To fight an enemy, he must be seen. Visibility means more than having good vision. It is important to know where to look for an enemy prior to and during an engagement. There are times when he will be seen, then maneuver into a blind area and will reappear after a brief interval. To regain sight of him, the area where he is going to must be scanned. Learn to use the mirrors. Fly with the shoulder harness unlocked to permit leaning forward. Try different seat positions to find the spot that will give you the maximum rearward visibility. Learn to move around in the cockpit so a forward and aft scan can be maintained. Learn to feel and fly left-handed, because in a right defensive turn it will be necessary to push yourself away from the seat with your right hand in order to see back at 5 o'clock. A properly fitted helmet and mask are a must to provide maximum upward visibility. This can be assisted by using a thin helmet liner pad in front and contouring the visor to seat firmly on the oxygen mask.

AFTERBURNER

Afterburner provides instant thrust augmentation and rapid fuel depletion. For the most effective use, light afterburner in a nose down, low g run when acceleration is required or after the nose attitude is established and a zoom is necessary. A common mistake is "back stick, burner now." Don't use afterburner in a vertical pullout. It will increase your radius of turn and waste fuel. The afterburner approaches maximum efficiency at high subsonic and supersonic speeds with a one g load. It is inefficient at slow speeds and high angles of attack. If the aircraft is at a slow speed and there is a need to gain vertical potential, consider the fuel cost versus advantage to be gained and if justified, use the afterburner. A burner light will cost 50 pounds of fuel, and will leave a puff of fuel in the air which is visible for miles. Check for afterburner reliability. It could be critical to select afterburner, and have the nozzles come open with no lightoff.

RADIO

Keep transmissions brief but complete. Occasionally, while twisting around in the cockpit, the communications plug will pull loose. If nothing has been heard on the radio for a while, check the plug. When working with a partner, keep him informed. Call if he cannot be seen. It is suggested that a single, easily remembered call sign be used to designate each team. It is highly recommended that communications leads be taped together.

BOGEY CALLS

There are two types of bogey calls. One type is for information only and consists of the following parts in the order indicated: (1) flight call sign, (2) number of bogeys, (3) position with reference to clock code, (4) altitude in reference to flight, (5) approximate range, (6) direction of flight, and (7) any amplifying remarks: for example: "DEVIL, TWO BOGEYS, FOUR O'CLOCK, RIGHT, LOW, FOUR MILES, GOING AWAY, NO THREAT."

The other and more important bogey call requires action, and the command to react should follow the flight call sign, for example: "DEVIL, HARD RIGHT, BOGEY, FOUR O'CLOCK, RIGHT LEVEL TWO MILES, CLOSING, LOOKS LIKE A FITTER." The addition of an action command with the general direction to turn ensures the initiation of the proper action to nullify or minimize any attack. The best counter is to break into the direction from which the attack is being made whether from above, below, or level. Therefore to signify elevation along with direction, altitude should be termed

by 60 degree altitude sectors. From directly overhead to 30 degrees above the horizon should be designated "OVER;" from 30 degrees above to 30 degrees below, no signification necessary; from 30 degrees below to directly underneath should be designated "UNDER." A proper call would then be: "DEVIL, BREAK LEFT, UNDER, TWO BOGEYS, EIGHT O'CLOCK, LEFT LOW, ONE MILE, CLOSING FAST."

THE SUN

Assuming the enemy has maneuvered to your 6 o'clock position, and a bright sun is available, your immediate action should include the possibility of using the sun. Consider a defensive pull-up for a vertical turn reversal into the sun. The enemy will have to commit himself to one side or the other. Turn into him when he is committed. This will increase his overshoot and provide more separation to work with for a followup maneuver, either a vertical scissors or a run for separation.

The sun can render a heat seeking missile attack ineffective. Attack out of the sun if there is a choice. When following the enemy up into the sun, block out the sun with your hand to keep him in sight. Move below your opponent to keep him out of the sun so he won't be able to see your aircraft, then wait until he makes his turn and follow him.

CONTRAILS

Know the bottom and top of the contrail level, and plan your cruising altitude accordingly. An aircraft

in the contrails can be spotted as far as 50 miles. A vertical turn near the contrail level may cause contrails which can attract enemy fighters in the area.

CLOUDS

Clouds can provide an effective defensive environment. Cloud penetration will preclude both visual acquisition and effective use of the enemy's IR missiles. Moderate rain may obliterate AI radar tracking. A hard vertical maneuver on instruments will probably lose the average enemy fighter pilot. It is possible to follow an aircraft in thin clouds, especially if the engine produces a smoke trail. Keep his smoke just above the canopy, and his trail may be seen about 1,000 feet ahead, depending on the cloud thickness.

AGGRESSIVENESS

The capability of the F-8 is of little value without a mature, well-trained and aggressive Fleet fighter pilot to bring this weapon system to bear against an enemy. There is a definite need for a full knowledge of air combat maneuvers in the Crusader. The F-8 is being used, and will be used throughout its service life, as a day visual fighter as well as an all-weather fighter. Your approach to this task should not be one of reckless abandon. The true Tiger is not an aviator identified by departures from tested and proven tactics and procedures, but one who is serious and well-trained. He must have a complete knowledge of his own and his aircraft's capabilities and limitations. Be aggressive, be smart and, most important, be mentally prepared.

COMBAT FORMATIONS

A combat formation is used whenever mutual support will provide a tactical advantage. This support results in increased lookout capability and concentration of firepower, provides for defense against attack, and simplifies the radar tracking control problem of CIC. Whenever mutual support does not provide a definite tactical advantage, aircraft should not fly in formation.

THE F-8 SECTION

Offensive combat formations are used on fighter missions where destruction of enemy aircraft is the primary objective. The basic combat unit of Navy fighters has traditionally been the four-aircraft division. With the advent of higher-performance fighters armed with weapons of greater capability, the basic fighter unit has become the two-aircraft section. The section possesses in adequate amounts the necessary ingredients of lookout capability, maneuverability, and effective use of the weapons carried. Most important, however, is the fact that the section is harder to split in an engagement. The independent tactical section is easily adaptable to carrier operations for the following reasons:

a. Ease of rendezvous. The section is in tactical formation immediately after catapulting and ready for vector to station or intercept.

b. Ease of recovery. The section is together upon return to the carrier and can be treated as a single aircraft under all but the most unfavorable weather conditions.

c. Radar control. The section can be treated as a single aircraft for both GCI/CCI air control, or for broadcast control.

Designating the section as the basic unit does not preclude grouping sections together if the mission requires it.

LOOKOUT DOCTRINE

Success in air-to-air combat begins with the detection of the enemy, and the earlier the sighting the better. Any combat formation must be designed to give the best opportunity for spotting the enemy before he is in a position of advantage, or before he sights the friendly formation. This requires that all eyes in the formation be available for scanning the surrounding area, unhindered by the necessity of concentrating on other planes in the formation for rigid station keeping. A loose formation is required with all aircraft spaced so that pilots may keep their eyes diverted from the leader for long periods of time and still not risk collision or loss of position. Since the tail sector is the most vulnerable area and the most difficult to cover visually, the necessity of placing aircraft nearly abeam of each other for astern lookout is also apparent. For lookout only, the farther apart they are, the better coverage of the tail sector of the aircraft abeam. However, too great a distance apart renders mutual assistance impossible, even when early sight contact is made. Positioning aircraft in combat spread formations is necessarily a compromise.

Target factors affecting visual detection range are:

a. Contrast of the target against its background

b. Distance and altitude

c. Target cross sectional size

Generally, the visual detection range for operational closing velocities (300-500 kts) will be approximately:

a. Low contrast, small fighter	2 to 3 miles
b. High contrast, small fighter	About 5 miles
c. Medium contrast bomber	20 miles or greater

An effective lookout doctrine provides mutual cross coverage for both members of the flight. To provide effective cross coverage requires a systematic visual scan, and a coordinated radar search pattern. The technique of effective scanning requires constant practice which will improve visual acuity and ability to see targets that otherwise might pass undetected. In order to insure detection at maximum distance, an effective visual search pattern must be used. The eyes should be focused on a point beyond five miles such as picking out an object on the ground. With this focal point, the depth of field approximates a range of one mile to infinity. The most significant effect gained from employing definite search patterns and recommended techniques is the increase in detection rates by all flight members. Use of good search techniques must be constantly practiced by all members of the flight in order to attain and maintain optimum effectiveness in combat. When enemy aircraft are sighted, they must be kept in sight. At high altitudes particularly, glancing away after sighting nearly always results in loss of the contact because of slight changes in position of the contacts, or more likely, changes in the focus of the eyes. The term "padlock" means "I will keep the enemy in sight," and "I have the lead." When one group of enemy planes has been sighted, there is a good possibility that others are in the area and the lookout should be intensified by those not in sight contact with the first enemy group. Nothing is worse than to counter one attack successfully and be jumped from the rear by a second enemy group that was not seen prior to the attack. The difficulty of gaining sight contact on an enemy at high altitudes is considerable, even when the approximate bearing is known. The development of airborne radar for target acquisition has been a major advancement and a must in modern aerial warfare; however, there is no substitute for an alert lookout by all members of the flight. If visual spotting is to be at its best, a combat formation must be flown wings level as much as possible. When a flight is turning, pilots tend to concentrate on the mechanics of maintaining position instead of looking around.

MANEUVERABILITY

A combat formation must possess a high degree of maneuverability. It is ineffective to spot the enemy expeditiously if the attacking formation scatters on the first turn. Conversely, the most maneuverable of all formations, the column, is obviously unsuitable for combat because of its poor lookout capability. Here again, a compromise of some sort must be made.

INTERNAL CONTROL

The problem of maintaining the integrity of any formation in a combat situation is one of prime importance. No system yet devised will assure constant control by the flight leader; nor has one been found that does not break down somewhat in an engagement. However, the longer the team can be kept together without compromising any of the other essential elements, the better is its offensive or defensive potential. The desired basic combat formation is one which does not break up readily and which has sufficient offensive or defensive potential to function as a unit.

INDIVIDUAL MANEUVERS

INTRODUCTION

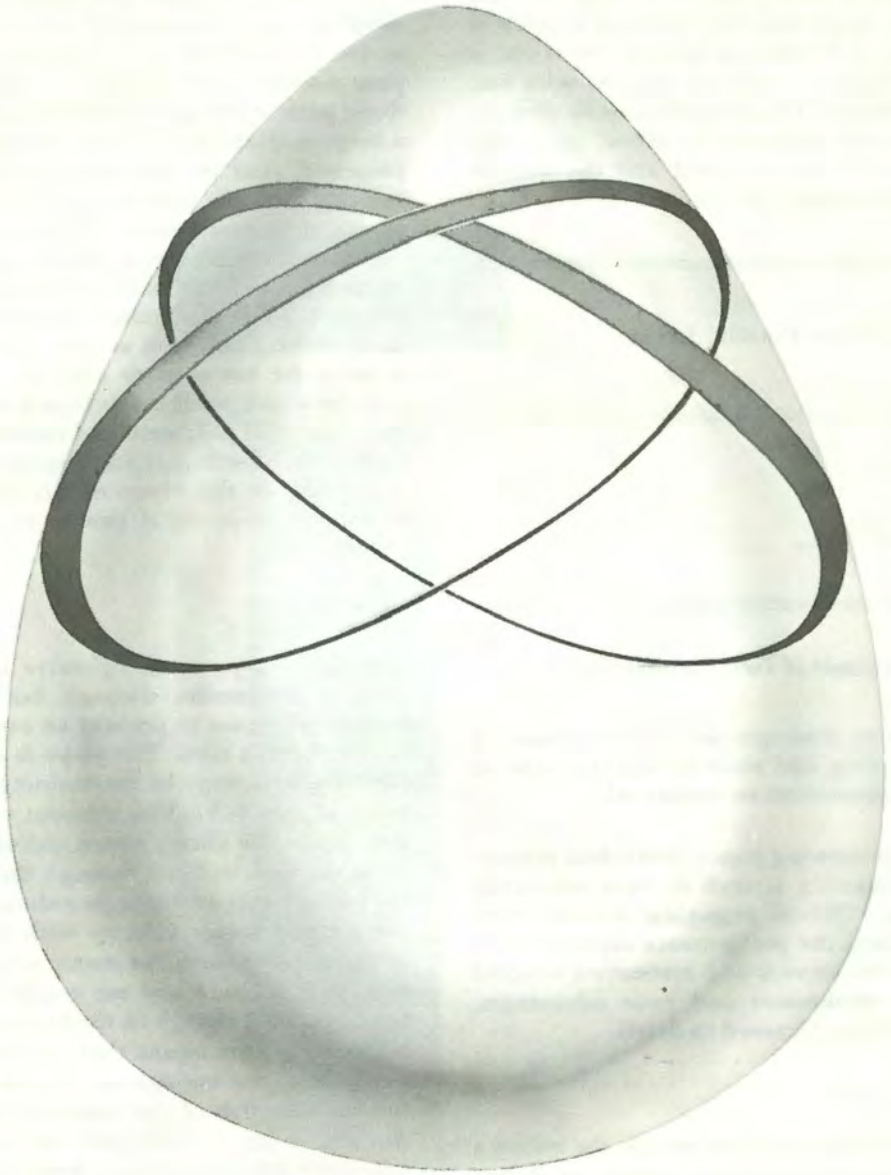
To understand fighter vs fighter combat, a complete knowledge of spatial relationships is necessary. Many pilots believe there are an infinite number of situations and solutions in a given tactical encounter. Such is not the case! The field in which a fighter pilot must operate is three-dimensional and finite. The pilot must be able to visualize this area and must *know* the basic combat maneuvers which can be employed to use the area to his tactical advantage.

Two concepts, important to visualizing the area of sky in which combat takes place, must be understood. These are the concepts of the egg-shaped spheroid and of the two parallel straight lines.

As the name implies, the field of the egg-shaped spheroid resembles an egg, with an elongated Northern hemisphere (figure 1–3). The spherical shape is a result of a maneuvering fighter's turn and velocity capability while operating through three dimensions. The elongation results from the effect of gravity (1g). The pilot has complete control over aircraft turn and velocity and can learn to effectively use the effects of gravity to advantage.

To gain the advantage in a fighter vs fighter situation, turn and/or velocity must be changed with respect to the opponent. Either, or both, can be accomplished by employing a two-dimensional maneuver through three-dimensional space, or by employing a three-dimensional maneuver. The pilot who can best visualize turn, velocity and g effects in terms of the egg-shaped spheroid has a distinct advantage (remember the opponent is operating in a different egg-shaped field).

Field of Maneuver



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Figure 1–3

The concept of the two parallel straight lines can be demonstrated by imagining that the lines are two identical lengths of flexible wire lying on a table. The left end of each wire is fixed, but the right end of each is movable. If a loop is formed in one of the wires, a three-dimensional bend is produced and the wire has, in effect, been shortened. This example can be directly related to an aircraft executing a barrel roll. The forward velocity vector is decreased and the aircraft is displaced laterally in space. See figure 1–4.

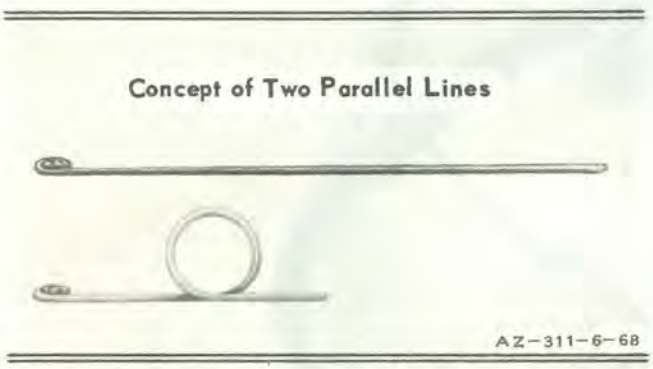


Figure 1-4. Concept of Two Parallel Lines

These two elementary concepts are the true basis of air combat maneuvering and must be kept in mind as the various combat maneuvers are explained.

As discussed on the following pages, individual maneuvers consider the opposing aircraft to have essentially similar performance. When engaging aircraft with dissimilar performance, the performance capabilities of the opponent must be known and maneuvers selected which exploit his weaknesses and your advantages. Later this subject will be discussed in detail.

THE ATTACK

The purpose of the attack is to get within the enemy's angular velocity cone. As you attack, expect the enemy to perform a defensive turn into the attack to rotate his angular velocity cone away. If you attempt a pursuit curve attack from long range, angle-off will increase and g will continue to build as range is decreased. As you attempt to decrease angle-off, expect the enemy to tighten his turn to prevent it. If the attack is continued in the plane of the enemy's turn, you may slide through his flight path and to the opposite side of the angular velocity cone. Under these circumstances, expect the enemy to counter with a turn reversal.

To prevent an early overshoot do not continue to fly a pursuit curve after the enemy initiates his defensive turn. Instead, attempt to generate a rate of turn almost equal to his. *Do not match or exceed his rate of turn, or you will be in front of him after 180° of turn.* Keep your fuselage nearly parallel to the enemy's and your flight path in the same relative direction. This prevents a large increase in angle-off and as firing range is approached, your position is nearer the enemy's angular velocity cone. To counter, the enemy is forced to tighten his turn much sooner and must maintain a max-performance turn for a longer period of time while attempting to force an overshoot. This costs the enemy airspeed, a loss of angular velocity, and a loss of future maneuvering potential as you close to firing range. As a result he has a more difficult time generating an overshoot and possible subsequent scissors. If the enemy exercises good judgment and excellent stick and rudder technique, he still may force an overshoot as the attack is pressed in the plane of his turn. To prevent an overshoot, yo-yo off if unable to stay inside his turn radius.

HIGH YO-YO

The high yo-yo is an offensive tactic in which the attacker maneuvers through both the vertical and horizontal planes to prevent an overshoot in the plane of the enemy's turn. The yo-yo is used to maintain an offensive advantage by maintaining nose to tail separation (figure 1–5). The moment you realize you can't stay inside the enemy's turn radius, roll slightly away from the turn and pull through the vertical plane. The purpose of this action is to reduce your turning component and vector velocity with respect to the plane of the enemy's turn. For maximum effectiveness, maintain back pressure and use rudder as primary control for directional change in the vertical plane. For proper perspective, this means that you roll toward the vertical plane just enough to provide an angle of bank smaller than that of the enemy's. Your flight path will describe an arc through both the vertical and horizontal planes (assuming the defender is turning, more or less through the horizontal plane) and you will be able to maintain nose-tail separation while turning inside the enemy. The control technique employed — back pressure with rudder as the primary control for directional change — not only allows you to reduce turn and velocity components to their smallest value, but also reduces your yo-yo apex. If rudder is not used as primary control for the roll into the yo-yo, you will be forced to relax back pressure, thereby increasing turn radius and velocity and decreasing induced drag. To

High Yo-Yo

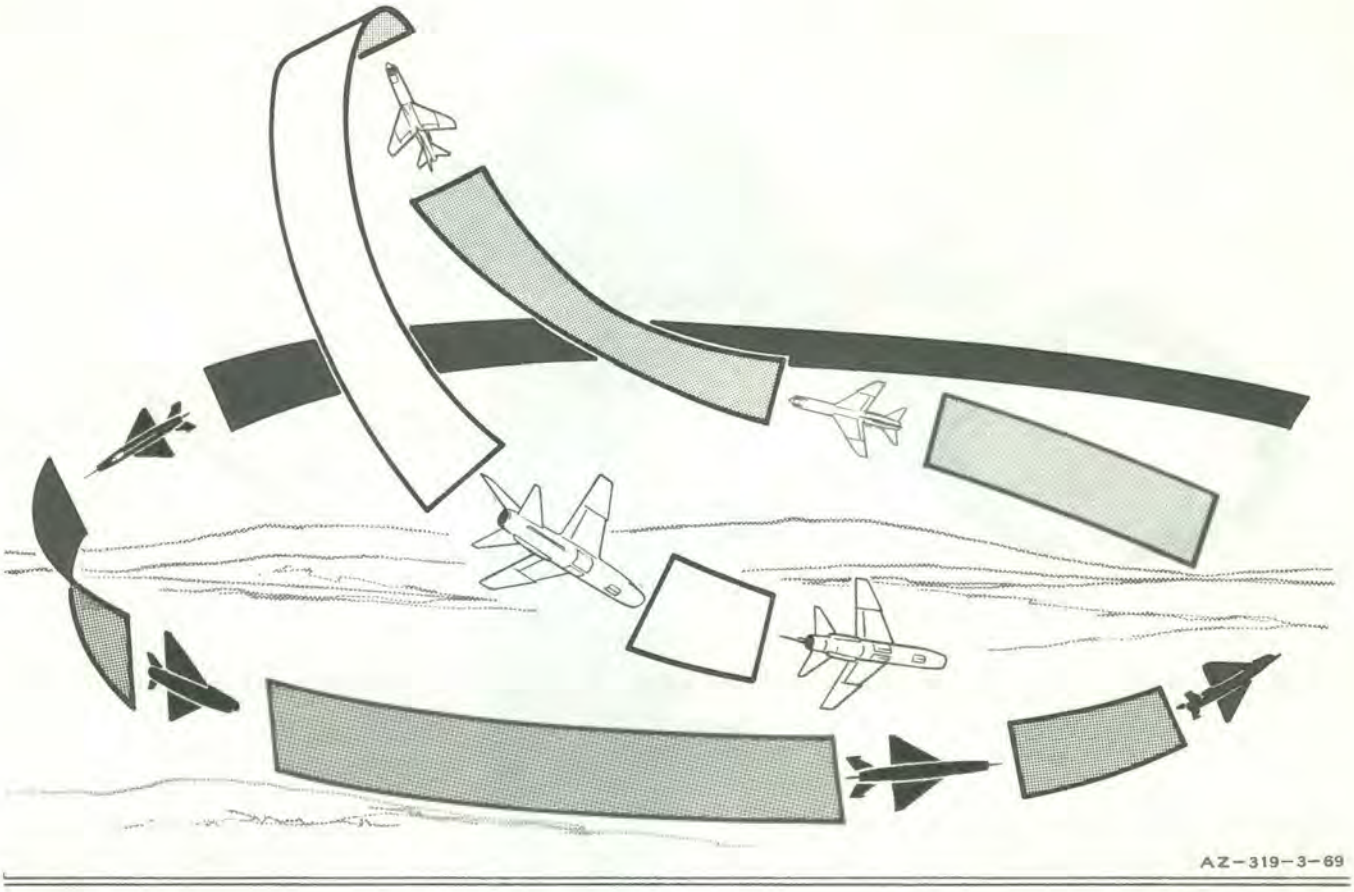


Figure 1–5

maintain nose-tail separation and prevent a turn overshoot in this event, you will be forced to yo-yo to a higher apex point. This provides the enemy the option of diving away to gain separation and, of course, places you in an overhead attack with a negative delta Mach. If you attempt to employ ailerons and maintain back pressure, you may be forced into an overshoot and be caught in a scissors maneuver.

If the high yo-yo is used correctly, nose-tail separation will be maintained with little vertical displacement (low apex). You need only to roll off or slide down to the enemy's six-o'clock position.

If you have little nose-tail separation, employ a roll-off (barrel roll away from direction of turn). The roll reduces vector velocity along the axis of the roll which provides separation and thus prevents a possible overshoot. To perform the roll-off successfully, continuously release back pressure as you roll from 90° to the inverted position — 180° — then gradually increase back-pressure as you approach the 270° point. Continue the increase of back pressure until the 360° point. From the 180° through to the 360° point, employ top rudder. If this stick and rudder technique is not used, you may roll underneath the enemy in an obvious overshoot, which will seriously compromise your offensive advantage. The high yo-yo is not always the ultimate in countering a perfectly-executed defensive turn and a follow-up scissors. If the yo-yo is too far behind or too high, the enemy can relax g, light afterburner and dive away for separation. This leaves you in an overhead attack with a negative delta Mach. If you yo-yo high and maintain very little nose-tail separation, the enemy can pull up into the attack and secure a six-o'clock low position. If the high yo-yo is perfectly executed, the enemy still has an out if he exercises excellent judgment and skillful technique.

To counter your high yo-yo, the enemy must first play the attack in an attempt to force an overshoot (figure 1–5A). Naturally, he will expect you to yo-yo high to

Counter to High Yo-Yo

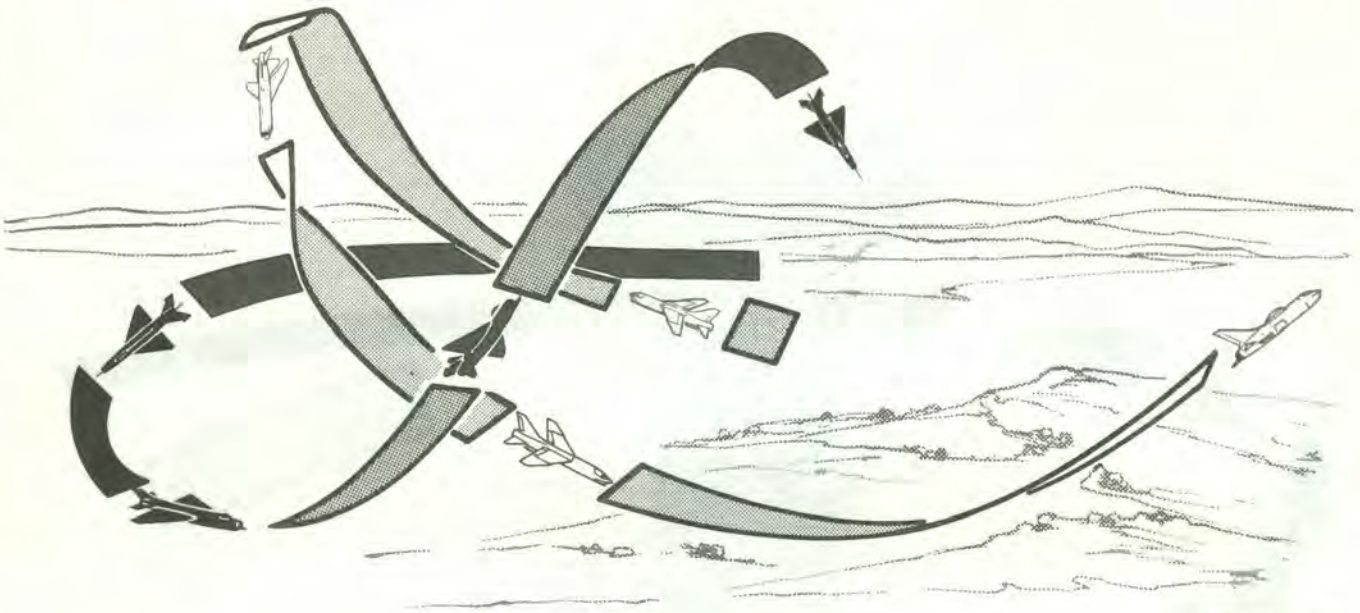


Figure 1–5A

maintain the advantage. He must now determine your relative position and attitude before making his next move. If you generate extreme vertical separation, the enemy must immediately relax g, light afterburner, and dive 180° away. If your high yo-yo is executed properly, the enemy has little opportunity to dive away. If he pulls up, he will position himself at twelve o'clock, and if he maintains his turn, he will dissipate his airspeed and angular velocity. You will then merely slide down to his six o'clock position and finish him off. To further understand the counter which the enemy must employ, let's examine the spatial relationships involved. Although you obtain a favorable position with nose-tail separation and a low yo-yo apex, you are not in the enemy's angular velocity cone so cannot deliver weapons at this instant. If the enemy takes no action, you will soon be in the proper position for weapons delivery. Realizing this, the enemy knows his salvation lies in maneuverability–airspeed and angular velocity. Therefore, when you yo-yo off, he must relax g and maintain his angle of bank. As a result, his nose will drop slightly below the horizon, thus maintaining his maneuvering airspeed. Upon observing the greater turn radius and the nose-down condition, you have the option of maintaining the yo-yo apex or attacking the descending enemy. It is obvious that you must press the advantage. If you do not, the enemy will increase separation and place you in an undesirable overhead position with a negative delta Mach. Knowing this, you drop the nose and attempt to set up for the attack. Observing your commitment, the enemy employs top rudder and back pressure to pull up into the attack. If he waits for the commitment and counters correctly, you will be placed in a nose-low condition, while he has a nose-high attitude. In relation to the enemy's, your airspeed will be higher and your rate of turn will be less. At the same time, since you are approaching the horizontal position and the enemy the vertical position, your radial g (with respect to total g) is less than the enemy's. This means that your radius of turn must be greater (radius of turn = fighter velocity squared divided by rate of turn). The result is obvious; you will be forced into an overshoot, below and forward of the enemy's line of flight. To gain the offensive, the enemy need only roll-off or slide down to your six-o'clock position. Once again, if the enemy has little nose-tail separation, and enough vertical displacement, he should employ the roll-off in order to achieve an advantage.

To successfully maneuver against the enemy's countering pull-up, you must keep in mind the relationships involved: the pull of one-g gravity causes your airspeed and turn radius to increase with respect to the enemy (figure 1–5B). Therefore, your best course of action

Counter to Defensive Pull-Up

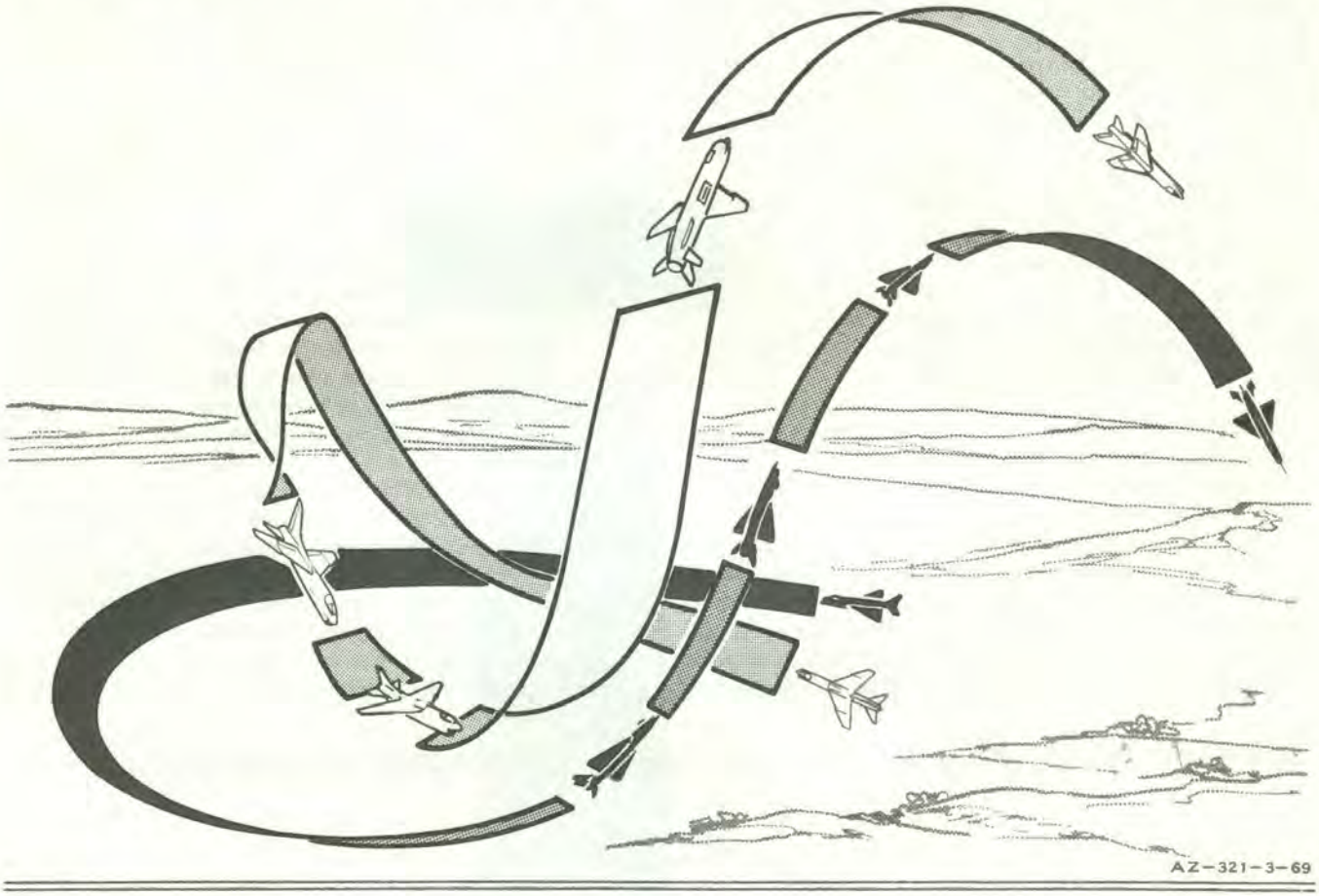


Figure 1-5B

lies not in turning, but in maintaining an airspeed advantage. At the instant you observe the enemy's rolling pull-up, roll one quarter turn away from his line of flight. This action will maintain nose-tail separation. At the same time, begin a smooth pull-up behind the enemy's line of flight. Play the pull-up so the enemy's original altitude is not overshot. (An overshoot here would be the same as an overshoot in the horizontal plane before executing a high yo-yo). Since you started from a high position, your airspeed at the bottom of the pull-up will be greater than the enemy's at the same level, with a consequent advantage. If the enemy continues his pull-up, zoom above and roll behind him — the airspeed advantage has paid off. If the enemy attempts to dive away, cut off through the horizontal plane and move into his six-o'clock position.

The enemy can counter your one quarter roll-away. When near the bottom of your pull-up, your airspeed is max; while the enemy, near the top of the zoom, has minimum airspeed. You have nose-tail separation but have also generated lateral separation in the vertical plane. To counter, the enemy must rotate his angular velocity cone away from you. To do this, he turns from a nose-high to a nose-low position, through the vertical plane, into the attack. This places him in a nose-low, nose-quarter attack, with his airspeed increasing while yours is decreasing. He now relaxes g, lights afterburner and dives for separation in an escape maneuver. To acquire a six-o'clock position, you must turn 180° through the vertical plane, meanwhile continuing to dissipate airspeed. By the time the maneuver is completed, you are in an overhead attack with a negative delta Mach, well outside gun range.

BARREL-ROLL ATTACK

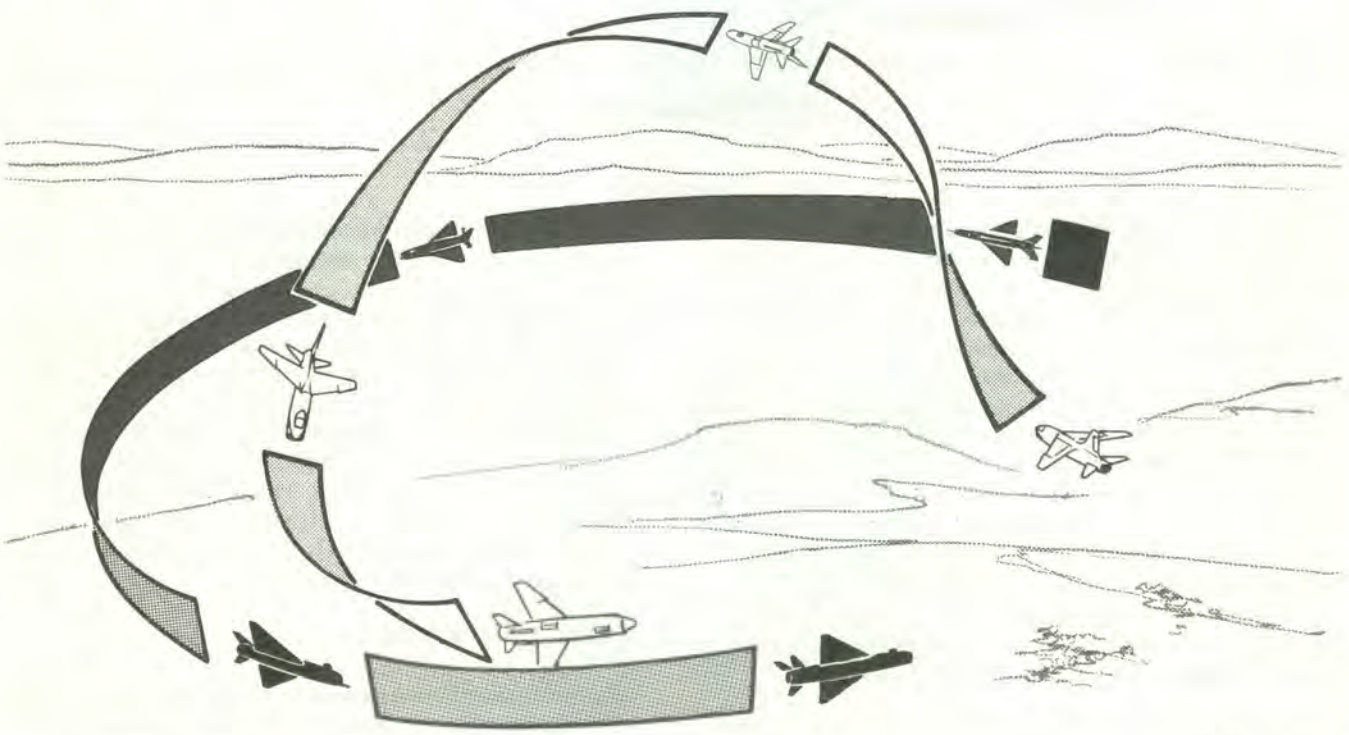
The high-speed yo-yo appears to be an excellent offensive maneuver to use any time you have a rate of closure and cannot match a countering defensive turn. Generally, this is true; however, in a situation in which the attack is at high angle-off (40° or more) and long

range (10,000 feet or more), use of the high yo-yo is questionable. Under these circumstances, the yo-yo would require an extremely high apex to maintain nose-tail separation and to stay inside the enemy's turn radius. Naturally, if this occurs, expect the enemy to immediately dive for separation and airspeed. You are then in an overhead attack with a negative delta Mach and must initiate a new attack. Noting this, the enemy turns into the attack and generates a high angle-off at long range, and forces you into another yo-yo with high vertical displacement. Once again, you start a new attack and the process repeats itself. The result is obvious: if the enemy counters each attack successfully, little additional advantage is gained and a stalemate exists. The purpose of the barrel-roll attack is to prevent this stalemate from developing. The barrel-roll attack is illustrated in figure 1–5C.

Geometric examination of a high angle-off, long-range attack reveals that the yo-yo is not the best maneuver to use. Instead, a maneuver is required which reduces angle-off and permits you to slide into the enemy's angular velocity cone, without his being able to gain longitudinal separation. As previously stated in the introduction to fighter maneuvers, it is possible to reduce turn and velocity by two methods: (1) through both the vertical and horizontal planes by employing a two-dimensional maneuver (yo-yo), or (2) maneuver through both the vertical and horizontal planes by employing a three-dimensional maneuver (barrel-roll). Thus far, emphasis has been on the first method. Now, both methods will be employed to reduce airspeed and angle-off, then to regain airspeed to prevent longitudinal separation.

How is the three-dimensional concept applied? If you barrel-roll in the plane of the opponent's turn, your vector velocity is reduced along the axis of the roll. However, the roll will provide a line of flight tangent to your intended turn, which increases angle-off and improves the possibility of an overshoot. If the roll is conducted in the vertical plane–combined with a high yo-yo–there is a different result: (1) there is less vertical displacement than in an ordinary yo-yo because vector velocity along the axis of the roll, in the vertical plane, is diminished; (2) component velocity, in the plane of the enemy's turn, is diminished as a result of the yo-yo and the roll; (3) aircraft velocity is greater as a result of the lower yo-yo apex and the shortening effect which the roll has on the velocity vector in the plane of the enemy's turn. The shortening effect diminishes your rotation angle through the vertical plane. This provides less speed decay, hence greater aircraft velocity is maintained; and (4) there will be no overshoot as a result of the roll, since the roll is not conducted in the plane of the enemy's turn. If the yo-yo

Barrell Roll Attack



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Figure 1–5C

with a roll is started below the enemy, the opportunity to gain a favorable position is increased. By starting from an inside-low position, you lower the apex of the maneuver. This provides the enemy less opportunity to gain separation. The problem is to be able to apply this concept of turn and velocity against the enemy.

To set up the maneuver, dive below and inside the enemy's defensive turn. Assume that you have the range/angle-off relationship specified above, and a dive below will provide some additional airspeed. However, this will not increase vertical displacement above the enemy, since airspeed can be easily killed during the forthcoming rotation through the vertical plane. If you approach the target from below and at a high angle-off, continue to cut off in an attempt to reduce angle-off until reaching the pullup point. Pull up on the inside of the enemy's defensive turn, then barrel-roll away from the turn; ie, if the defensive turn is to the left, roll right; if the turn is to the right, roll left. The roll is not a high g barrel-roll (you are trying to kill vector velocity, not aircraft velocity). As you roll nose-high through the inverted position, play back pressure and kick bottom rudder to obtain a nose-low 270° change of direction (see figure 1–5). From the inverted position to the 270° point of the roll, 1g gravity assists in gaining a rapid change of direction toward the enemy's six-o'clock position. If the entire maneuver, from pullup through the roll, is on the inside of the enemy's defensive turn, you will be above him, at a reduced angle-off and in position to dive below his line of flight to six-o'clock low. Longitudinal separation will not be great, for two reasons: (1) Vector velocity is reduced, but a higher aircraft velocity is retained; and (2) the entire maneuver is performed inside the enemy's turn radius.

There may appear to be certain alternatives to counter the barrel-roll attack, such as a high g roll by the enemy when you perform the 270° change of direction, or a pullup under the same circumstances. The high g roll is ineffective because it causes the enemy's line of flight to be tangent to his defensive turn. In addition, his vector velocity will be reduced. As a result, you can easily play his maneuver to slide toward his six-o'clock position and have less longitudinal separation. The pullup is ineffective, since you are not committed to a nose-low position when rolling from the inverted position. Instead, top rudder may be used. Since the enemy must roll away from his defensive turn to execute a pullup, you have sufficient longitudinal separation and time to play top rudder to roll toward his six-o'clock position. The only effective counter against a properly executed barrel-roll attack is a dive for separation and airspeed. The moment you start the pullup, the enemy should turn nose-low toward the pullup, relax g, light afterburner and dive for separation. This forces you to perform a 180° change of direction in the vertical plane even though you use the roll-away. If considerable g is pulled to acquire this change of direction, airspeed diminishes considerably with respect to the enemy. If you play the maneuver with less g, vertical displacement is greater. In either case, you are in an overhead attack with a negative delta Mach.

To maneuver against the enemy's counter, deception may be employed. The purpose of deception is to prevent the enemy from diving for separation. Instead of pulling up inside the enemy's turn from an inside-low position, pullup to the outside of his turn, thus maintaining nose-tail separation. To the enemy, this appears as an overshoot. Therefore, expect him to reverse nose-high, in an effort to scissor you forward. However, if you play the maneuver properly — overshoot and zoom — this will be impossible. You have the advantage in terms of airspeed, nose-tail separation, and a high rotation angle in the vertical plane. This means that you may zoom above and behind, but outside the enemy's turn. He will be unable to match your zoom. If the enemy reverses (he most likely will), you will be above, behind, and to the inside of his turn. This will reduce vector velocity, provide nose-tail separation and permit a roll down toward his six o'clock position. He will be in a poor position to counter, since his airspeed and angular velocity are diminished as a result of his turn and nose-high reversal. Should he attempt to pull up into you, employ top rudder and roll-off toward his six-o'clock position. If he dives away, employ bottom rudder on your roll-off to prevent separation. In either ase, you will be in a favorable position. If the enemy does not react with a reversal to counter the overshoot and roll-off, but instead dives away for separation, he will place you in an overhead attack with a negative delta Mach. The separation from this barrel-roll attack will be greater than from the one conducted on the inside of the turn. It is difficult to determine which attack is best. However, if the enemy's conditioned reflexes are oriented toward a scissors maneuver in the event of an overshoot, employ the outside method; if not, employ the inside method.

The barrel-roll attack, or roll-off maneuver, need not be limited to the conditions specified above. It may be employed at shorter ranges and lower angles-off. The purpose is to reduce rate of closure and angle-off so that the enemy has little opportunity to gain separation. It is particularly effective when the enemy has superior turning performance.

LOW YO-YO

Assume you are at six o'clock, at long range, without a rate of closure. To gain a more favorable position, you must be able to cut off and close upon the enemy, and this is the purpose of a low yo-yo (figure 1–5D). To employ the low yo-yo when in a turning fight, simply

Low Yo-Yo

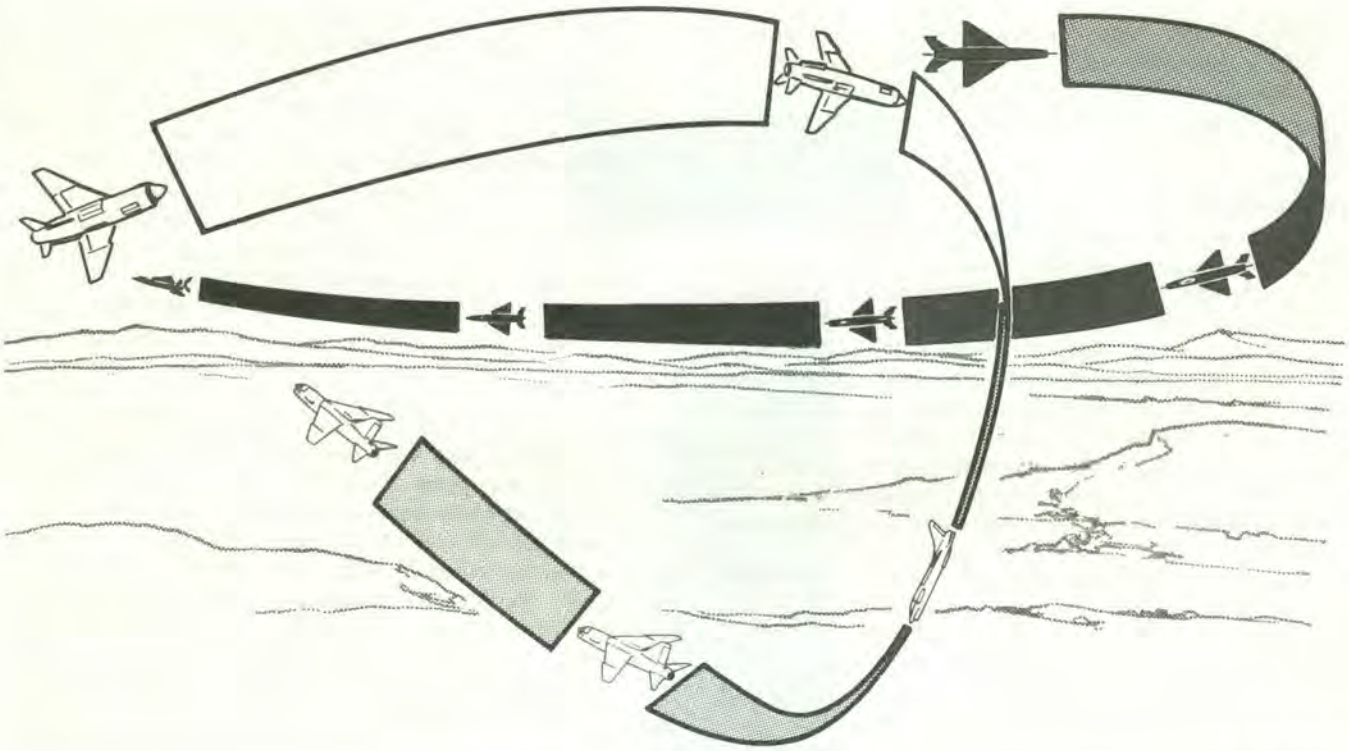


Figure 1–5D

maintain bank and lower the nose to the inside of the turn. You are now turning through both the vertical and horizontal planes. The pull of gravity increases aircraft velocity, thus increasing turn radius through the vertical and horizontal planes; however, in the horizontal plane, the plane of the enemy's turn, your turn radius is decreased (in this plane, turn radius is only a component of actual turn). As you turn below and inside the enemy, angle-off and airspeed increase and your distance decreases along the horizontal plane. To prevent an overshoot, you must pull up and zoom toward the enemy's six-o'clock position. The entire maneuver must be accomplished prior to reaching the enemy's line-abreast position. If done correctly, you will be at a reduced angle-off and at a diminished range. If still not in a lethal position, repeat the process. You gain an advantage in employing this maneuver, because airspeed loss is less than the airspeed lost by the enemy (assuming he is in a level turn). When you dive to the inside, airspeed increases and angle of attack decreases. The increased airspeed provides greater airflow mass to the engine, hence the engine generates more thrust. The decreased angle of attack reduces induced drag and as a result, in the dive portion of the maneuver, you not only have an airspeed advantage, but also a thrust advantage. On the pullup to the horizon, angle of attack and induced drag increase. This prevents any further increase in airspeed. However, at this point, you still have a considerable airspeed advantage. In the zoom portion of the maneuver, the pull of one-g gravity starts to diminish airspeed, and the loss of airspeed starts to increase angle of attack; however, the angle of attack is less than the enemy's because of the greater radial g available in the vertical and horizontal plane as compared to the horizontal plane alone. Because of this, less airspeed is lost in a low yo-yo than is lost in a horizontal turn through the same distance. Therefore, you gain a more favorable position even though you fly through a greater distance.

If you employ afterburner, the maneuver is even more effective, even though the enemy may counter in a like manner. The afterburner can best be used during the descent and zoom portion of the yo-yo, not during the

pullup to the horizon. If afterburner is used from pullup to the horizon, the component of afterburner thrust acts in the same direction as the pull of gravity. Unlike max-power in a horizontal turn, this causes a wider arc during the pullup which may reduce effectiveness of the maneuver. On the other hand, if considerable longitudinal separation exists, and the low yo-yo may be performed inside the defender's turn, employ afterburner throughout the entire maneuver. This will quickly reduce range and permit a zoom into the enemy's angular velocity cone.

The enemy cannot effectively counter a properly-executed low yo-yo by tightening his turn, by initiating a reversal, or by performing a high g barrel-roll. If he tightens his turn, he dissipates airspeed rapidly to a point where he reduces angular velocity and increases his turn radius. You can then zoom toward his six-o'clock position without difficulty. You may even play the zoom out of a low yo-yo so that you overshoot his flight path in the horizontal plane. If he reverses, you roll off in a direction opposite his turn and toward his six-o'clock position. If he initiates a reversal as you start the low yo-yo, he will be turning away from the attack, hence rotating his angular velocity cone toward you. Simply pull up on the inside of the reversal and maneuver toward his six-o'clock position. The reversal allows you to reduce more g than is possible against a tight turn, and as a result rate of closure increases enabling you to gain a favorable position more rapidly.

To counter a low yo-yo, the enemy must rotate his angular velocity cone away from you. In other words, he must turn into the plane of the attack. An obvious countermeasure appears to be a diving turn the instant you begin your low yo-yo. This rotates the enemy into the plane of the attack and cancels a possible low yo-yo. Of course the fight will be forced to the deck rather quickly. If the enemy rolls out of the turn, you will be positioned at six-o'clock. Thus the enemy receives only a respite from a stalemate situation. The enemy must not only rotate his angular velocity cone away, but must also do it in such a manner as to completely nullify your low yo-yo. He can accomplish this in the following manner: the enemy allows you to dive below and inside his turn until you begin a pullup. At this point he is in no immediate danger, since you are diving away from his angular velocity cone. As you begin to pullup from a nose-low attitude, the enemy rolls away from his turn and zooms in the vertical plane in a banked attitude. By this action, he rotates his angular velocity cone toward your line of flight. Observing this, you continue the pullup in an effort to move toward his six-o'clock-low position. By the time the nose reaches the horizon on your pullup, the enemy will be nose-high in a bank toward you with considerably less airspeed than yours. At this point he rotates his angular velocity cone away from you by turning from a nose-high to a nose-low position, through the vertical plane, into the attack. This places the enemy in a nose-low, nose-quarter attack with his airspeed increasing while your airspeed is decreasing. He now plays his action according to your intentions. If you continue the zoom and turn 180° through the vertical plane without cutting off, the enemy relaxes g, lights afterburner and dives for separation. This places you in an overhead attack with a negative delta Mach. On the other hand, if you cut off and overshoot him in the vertical plane, he may employ a different counter, the vertical rolling scissors.

COUNTERING THE OVERHEAD ATTACK WITH A NEGATIVE DELTA MACH

In discussing previous maneuvers, many situations have been encountered in which the enemy dived for separation to gain maneuvering airspeed, thus placing you in an unfavorable position for an attack–overhead, with a negative delta Mach. Possible counters to this attack will now be discussed.

To elude you, the enemy need only rotate his angular velocity cone away from your line of flight. Against an overhead attack with a negative delta Mach, he may accomplish this in two ways:

a. Pull up from a nose low attitude, followed by a zoom in the vertical plane; or
b. Pull up to the horizon, wings level, and perform a defensive turn.

The moment the enemy observes you lining up for a possible missile shot, he pulls up and zooms in the vertical plane. Faced with this counter, you have two alternatives: (1) Cut off, in an attempt to secure a six-o'clock-low position as the enemy zooms through the vertical plane, or (2) do not cut off, but fly the same relative flight path as the enemy. If you are not careful, you will be enticed into a cutoff. This is what the enemy is actually hoping and waiting for. If you cut off, you do not take advantage of the pull of gravity to build up airspeed; therefore, airspeed at the bottom of your pullout, will be less than the enemy's at the bottom of his pullout. The cutoff and the resulting lower airspeed force you to reduce rotation angle in the vertical plane with respect to the enemy. You will be unable to secure a six-o'clock position and will be forced to accept a smaller rotation angle, hence a flight path overshoot in the vertical plane. Meanwhile, the enemy with his airspeed margin, can pull toward or past the vertical and execute a rolloff–not a loop–down toward your six-o'clock position. If you attempt to counter, by completing your zoom and rolloff, you will lose out because of your lower initial

airspeed on the first cutoff with the resulting smaller rotation angle. The defender will quickly gain an advantage and move toward your six-o'clock position. If you had not cut off on the initial pullup and zoom, but had pulled up and zoomed through the same arc as the enemy, you would not have lost the advantage. As the enemy reached the near vertical, you would be near six-o'clock. This means that he would be unable to successfully roll off and gain a six-o'clock advantage, since he would not have an overshoot in the vertical plane. If he did roll off, you would simply follow and gain a more favorable position. To prevent this, the enemy must turn 180° through the vertical plane and once again relax g and dive for separation. You will then be faced with the choice of attempting to cut off or to zoom past the enemy through the same turning point to complete a 180° change of direction. If you attempt to cut off and overshoot in the vertical plane, the enemy may employ the vertical rolling scissors as a counter. On the other hand, if you do not cut off, the overhead attack with a negative delta Mach will be repeated once again. To counter this second attempt, the enemy may execute the second alternative, a pullup to the horizon and a defensive turn, left or right. If you press the attack in a curved plane which intercepts the enemy's turn, you will perform a nose-low spiral. As range diminishes, your airspeed and g will build up. The enemy will tighten up his defensive turn as your range diminishes. If the attack is continued, the nose-low spiral will force you into an overshoot below the enemy. The result is obvious. The enemy simply rolls off and maneuvers toward your six-o'clock position. If you attempt to yo-yo out of the nose-low spiral before overshooting below the enemy's flight path, you must roll wings-level in order to pull up and zoom in the vertical plane. This maintains nose-tail separation, but it also provides lateral separation for the enemy. In this instance, the enemy has taken the advantage. After rolling wings-level you have a nose-low attitude while the enemy has a nose-level attitude. This means that you must pull up from this attitude to nose-level before zooming in the vertical plane. This may cause you to overshoot the enemy's flight path before you can execute the zoom. If, during your pullup and zoom, the enemy counters with a nose-high reversal, he will diminish his horizontal component. The result is obvious: you are forced in front by your pullup and zoom. The enemy will be in position at six-o'clock low.

MANEUVERING FROM AN OVERHEAD ATTACK WITH A NEGATIVE DELTA MACH

As previously discussed, you may expect two possible counters to an overhead attack with a negative delta Mach: (1) A pullup from a nose-low attitude, followed by a zoom in the vertical plane, or (2) a pullup to the horizon, wings level, followed by a defensive turn left or right. The purpose in discussing the overhead attack with a negative delta Mach is to point out maneuvers which can be used against either one of these counters.

As previously stated, if the enemy counters with a pullup from a nose-low attitude with a zoom in the vertical plane, you should fly the same relative flight path. By so doing, you force him to turn 180° in the vertical plane in an attempt to gain longitudinal separation. Geometrically examining this situation shows that you have an apparent choice of either cutting off the enemy in the vertical plane, or zooming past him through the same turning point to complete a 180° change of direction toward his six-o'clock position. If you attempt to cut off and overshoot the enemy's descending flight path in the vertical plane, expect him to counter with the vertical rolling scissors. This will cost you the offensive advantage. If you do not cut off, the overhead attack with a negative delta Mach will be repeated once again, and you will gain little additional advantage. To prevent either situation from occurring, employ a barrel-roll (roll away) in the vertical plane, as you start past the descending enemy. This will reduce the apex of your zoom, because vector velocity (along the axis of the roll) in the vertical plane is diminished. As a result, you will roll away through a 180° change of direction to a position at the enemy's six-o'clock-low position in the vertical plane with much less longitudinal separation. If the enemy repeats the pullup and zoom, followed by a 180° turn in the vertical plane, repeat the process to gain an even more favorable position. You may then set up for missile or 20mm cannon attack. To counter the roll-away, the enemy need only add back-pressure and roll toward the roll-away, or dive for whatever longitudinal separation he can get to employ his second alternative. If he rolls toward the roll-away, you will be at a high angle-off in the vertical plane. To maneuver out of this position, you must roll 180° toward the enemy's flight path. Meanwhile, the enemy can relax g, dive for separation and attempt his second alternative.

If the enemy counters with a pullup to the horizon, wings level, with a defensive turn left or right, you must not launch an overhead attack in a curved plane against the rim of his horizontal turn. If you descend inside the turning circle, you are not committed to generate a turn rate less than, and a turn radius greater than, the enemy, as would be the case if you had initiated a pursuit curve attack. By descending inside the horizontal circle you describe a nose-low spiral in which rate of turn, along the horizontal axis, is governed by the spiral or roll rate along the vertical axis. Radius of turn along the horizontal axis is governed by the slope of your descending spiral. If you increase roll rate (in the spiral) and steepen the spiral, horizontal turn rate increases and horizontal turn radius decreases. In effect, you will be pirouetting down the axle of the enemy's horizontal turn, which will cause an

excessive buildup of velocity for your forthcoming maneuver unless power is reduced. As you pull well inside and below the enemy's turning circle, roll out of the spiral and execute a pullup and zoom toward the enemy's six-o'clock position. (In other words, employ a variation of the low yo-yo.) If your airspeed is excessive and it appears that the resulting zoom may force you too high and/or to the outside of the enemy's turning circle, simply employ the barrel-roll attack.

To counter the inside-low maneuver (the low yo-yo or the barrel-roll attack) out of the overhead attack with a negative delta Mach, the enemy can employ the counters suggested for a low yo-yo and/or for the barrel-roll attack.

THE VERTICAL ROLLING SCISSORS

The vertical rolling scissors is a defensive, descending, rolling maneuver in the vertical plane (figure 1–5E). The purpose of this maneuver is to gain an offensive advantage if the enemy overshoots your flight path, and slides through your angular velocity cone while descending in the vertical plane. The following situations may be used to set the stage for employing the maneuver: (1) At high altitude, when you have a high Mach with a low indicated airspeed. In this case, you will be forced to perform a descending defensive turn to maintain future maneuvering potential. If the enemy, with a fair rate of closure, thinks you are attempting to gain separation, he may cut off in an effort to prevent it. Since his airspeed is higher, his radius of turn during the cutoff will be greater than yours. As a result, he can be easily forced to overshoot your descending flight path. (2) In a zoom maneuver in which the enemy is attempting to approach your six-o'clock position. Observing the enemy's position, use the pull of gravity and execute a 180° turn through the vertical plane in an effort to gain separation, thus placing the enemy in an overhead attack with a negative delta Mach. In an effort to prevent this, the enemy cuts off. During the cutoff, his radius of turn is greater than yours because of his higher airspeed, and as a result he overshoots your descending flight path. (3) A six-o'clock-low attack, in which the enemy is approaching his pullup point. Observing the enemy execute one of two maneuvers: An immediate defensive turn down into the attack, or a pullup and zoom followed by a 180° turn in the vertical plane down into the zooming enemy (this is the same procedure used as a counter to the low yo-yo). If in either of these cases, the enemy attempts a substantial cutoff he can be forced to overshoot your descending flight path.

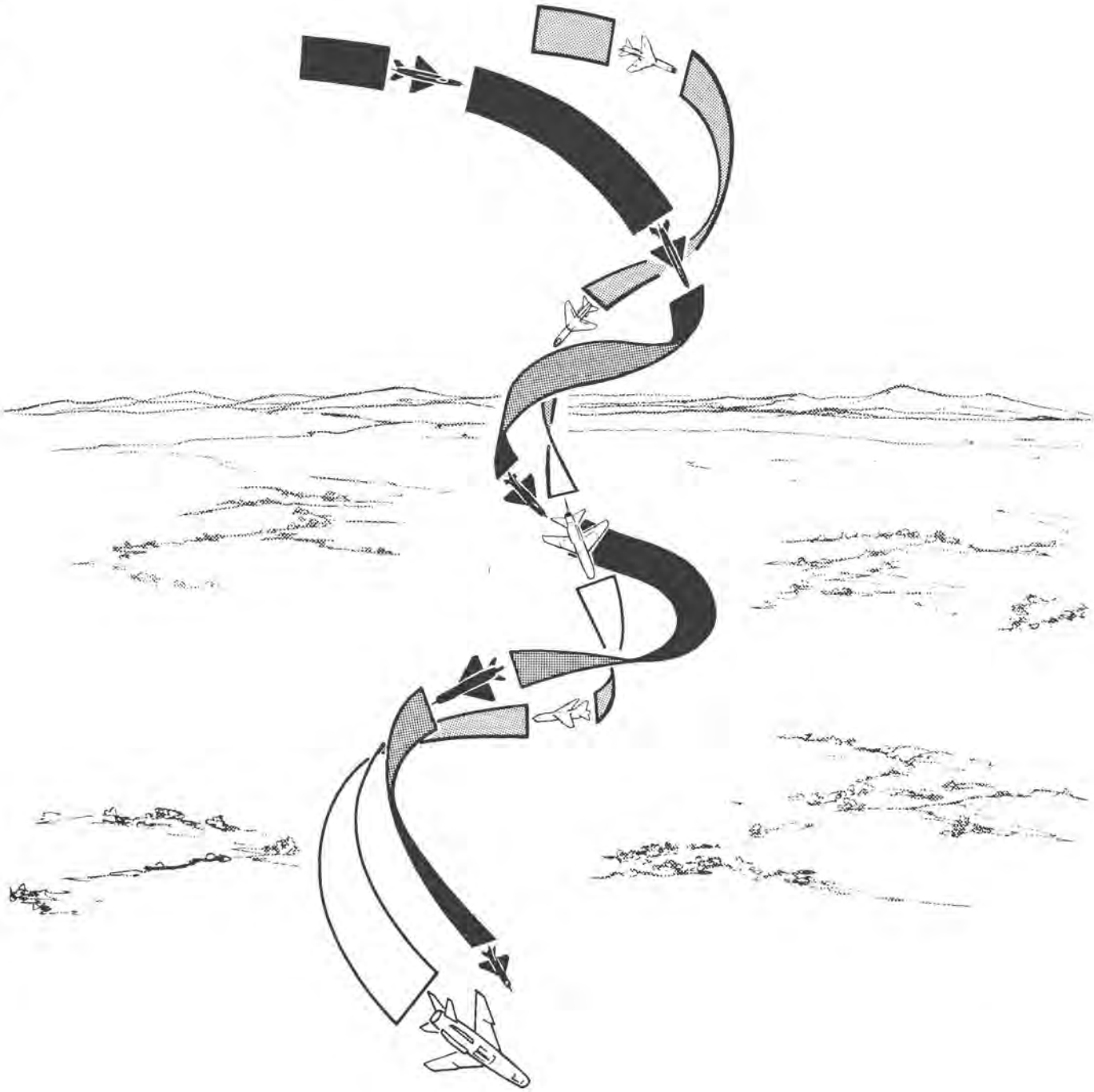
With the stage set, the mechanics of the vertical rolling scissors can now be discussed. Assume that you are zooming in the vertical plane with the enemy initiating a pullup toward your six-o'clock position. Observing the enemy's position, turn 180° through the vertical plane, down into the attack in an apparent attempt to gain separation. Observing this maneuver, the enemy knows he can either cut off or zoom and turn 180° through your turning circle. Since he knows that a turn through your turning circle will place him in an overhead attack with a negative delta Mach, he elects to cut off. Observing the cutoff, you know that the attacker will be performing his 180° turn through the vertical plane at a higher airspeed. Therefore, his turn radius will be greater and he will overshoot your descending flight path. At this time, reduce power to slow your rate of descent (you may use a little deception here by momentarily lighting afterburner, then reducing power, to make it more apparent that you are trying to dive for separation) then wait until the enemy overshoots your flight path and is committed to a nose-low attitude. At this instant, come in with back pressure and reverse-roll into the overshooting enemy. This will place you below the enemy and 180° out of phase, with a less nose-low attitude; hence, a lower vector velocity along the vertical axis. The enemy, noting that he is out of phase and is descending more rapidly than you are, will attempt to roll 180° toward your descending flight path. Observing his roll, roll in the same direction. This prevents him from flying into your six-o'clock position. At the same time, it prevents him from reducing his nose-low attitude. As a result, the enemy, with his higher vertical vector velocity, has rolled 180° out of phase, down and below you. You now have the advantage and need only roll into the enemy's six-o'clock position.

The enemy can counter the vertical rolling scissors if he does not attempt to cut off your descending flight path when he has a substantial airspeed advantage. Instead, as he climbs past you in your dive, he should roll away or barrel-roll to reduce his ascending vertical vector velocity, hence his yo-yo apex. This will allow him to complete his 180° change of direction with less vertical displacement and will position him at your six-o'clock position with less longitudinal separation and less negative rate of closure. To maneuver for a firing position, he need only maneuver against any of your forthcoming counters. It should be noted that the F-8 cannot achieve an advantage over most Communist bloc fighters in a slow speed scissoring environment, either wing up or down.

THE HIGH G BARREL-ROLL

There may come a time in a tactical situation in which you find that you can nullify a missile attack but have

Vertical Rolling Scissors



AZ-323-3-69

Figure 1–5E

less success in countering a followup gun attack. You must possess a high degree of skill in maneuvering to counter an aggressive, skillfully-executed followup gun attack. Under these circumstances, even the most proficient fighter pilot may find himself in a serious defensive position with an enemy at six-o'clock inside gun firing range. To get out of this situation, the enemy must be forced to overshoot your flight path. In other words, your angular velocity cone must be rotated in such a manner as to acquire lateral separation. Turn and velocity, married to the pull of gravity, determine the field of maneuver and your ability to rotate your angular velocity cone. You must employ these factors in proper perspective to gain an overshoot. This means that you must reduce turn and velocity more quickly than the enemy if he is to be forced out of your six-o'clock position. From previous discussions, it is obvious that a barrel-roll type maneuver offers the best opportunity to quickly change direction and reduce vector velocity. When the enemy is at six-o'clock, inside gun firing range, you must perform a max-performance or a high g barrel-roll to prevent him from matching your change of direction and reduction of vector velocity. Before initiating the maneuver, your only remaining problem is to determine in which direction the high g barrel-roll should be executed. To answer this, assume that you are in a defensive turn with the enemy at six-o'clock under the conditions specified above.

In an attempt to force the enemy to overshoot, you can either execute a barrel-roll over the top or a barrel-roll underneath out of your defensive turn. If you are at high speed (400 knots or more in the F-8), and perform a high g barrel-roll underneath, the pull of gravity will act in the same direction as your thrust vector. As a result, you will have considerable difficulty in reducing vector velocity much more rapidly than the enemy. If you perform a high g barrel-roll over the top, your thrust vector acts in a direction opposite the pull of gravity. In this case, you will reduce vector velocity much more rapidly than the enemy. It is obvious from this discussion that if you are in a high speed defensive turn with an enemy at six-o'clock inside gun firing range, you should execute the high g barrel-roll over the top in order to gain an overshoot.

If you do not have the speed necessary to execute the high g roll over the top, do not attempt to do so. The high angle of attack required to successfully accomplish the maneuver and the pull of gravity will cause speed to decay very rapidly. If you attempt to roll over the top, you will stall out and be unable to complete the maneuver. The enemy will set up at the six-o'clock position for an easy kill. With insufficient speed to execute a roll over the top, you should perform a high g roll underneath (in the F-8, this maneuver should be initiated with an airspeed of approximately 250 knots). In this situation, you use the pull of gravity to successfully complete the maneuver. The induced drag generated by the high angle of attack required for the roll will provide a deceleration greater than the acceleration generated by the pull of gravity. Hence, if you execute a high g roll underneath, you can still change direction and reduce velocity more rapidly than the enemy, since he must still maneuver with respect to you. Now that the use of the high g barrel-roll, both over the top and underneath, is understood, the mechanics of each maneuver will be discussed.

THE HIGH G BARREL-ROLL OVER THE TOP

The high g barrel-roll over the top (figure 1–5F) is used when an enemy is at six-o'clock inside gun firing range, and you are unable to shake him with a defensive turn. More specifically, the enemy should be at a fairly close range of about 1,500 feet or less. If he is at a range much greater than this, the high g barrel-roll, because it rapidly reduced your velocity, will serve only to bring him closer toward your six-o'clock position. You would be in a poor position to counter since you would have killed your maneuvering velocity.

With these conditions in mind, the moment you realize you cannot shake the enemy, execute the roll. To execute the maneuver properly, maintain back pressure and start the roll over the top without releasing g. Ease in stick back pressure, pulling into the buffet, and at the same time feed in full rudder in the direction of the roll. As the aircraft rolls through the wings-level position, the nose should be coming up through the horizon. Maintain full rudder and back stick so that the nose will be well above the horizon at the 90° position. The rudder controls the rate of roll and the stick controls the rate of deceleration.

It is necessary to keep rudder fully applied throughout the roll, whereas stick back pressure must be decreased due to the rapid decay of airspeed. If the enemy has followed around the roll, he will be forced to the outside of your roll. At the 270° position he will be high, toward the rear, and outside the roll. Look for him high in the direction of the roll (if the barrel roll was to the left, look for him on your left). As you complete the roll, strive to increase noseup attitude to further decrease your forward velocity vector. When the roll is properly executed and the enemy attempts to follow, he will be forced to the outside, below, and forward as the roll is completed. Simply roll or slide toward his six-o'clock position.

High G Barrel-Roll Over the Top

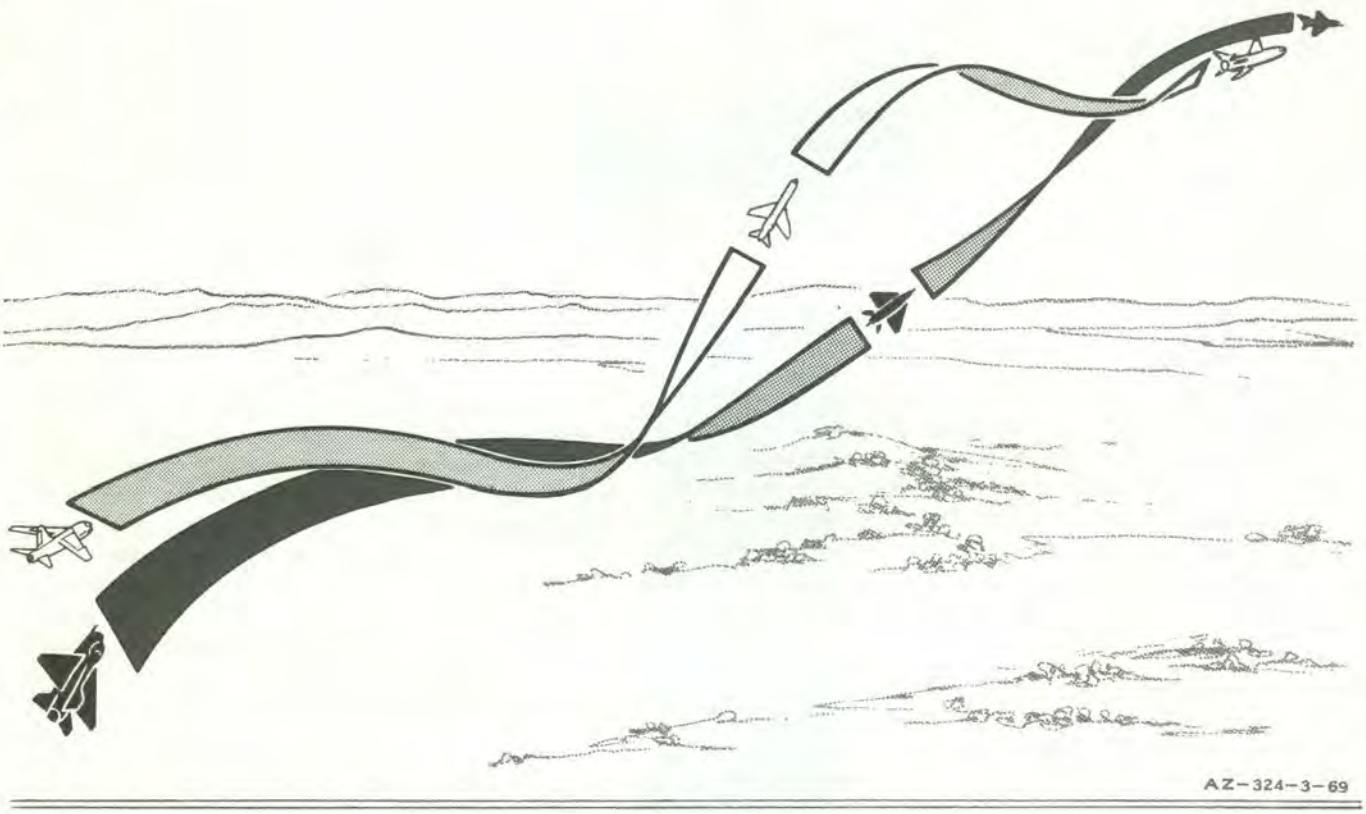


Figure 1–5F

Note

The high g barrel-roll is an unbalanced flight maneuver. If any aileron is introduced, there is a chance of a departure and subsequent spin.

To counter the high g roll, the enemy may attempt to yo-yo out the top of the roll or reverse-roll out the top in an effort to secure a six-o'clock position (figure 1–5G). If the enemy yo-yo's out the top, he is attempting to reduce his vector velocity along the axis of the roll by yo-yoing in the vertical plane. In this way he can maintain a six-o'clock-high position after you complete the roll. Therefore, you MUST ascertain the enemy's position as you approach the 270° point of your roll. You will probably be unable to determine his position prior to this, since the yo-yo out, or the reverse-roll, places him in a blind spot, toward the underside of your aircraft. If, at the 270° point, you see the enemy toward the rear at the top of your canopy ("top of the canopy" means the enemy is in the horizontal plane when you are at the 270° point of the roll) he has performed a reverse roll. If he is in this position, do not complete the roll. Instead, perform a horizontal turn into the enemy and force him to overshoot, then dive for separation. This places the enemy in an overhead attack with a negative delta Mach (do not attempt a scissors, since you do not have the airspeed after performing the high g roll). If, at the 270° point of your roll you observe the enemy to be extremely high and to the rear (off the left side of the canopy in a high g roll to the left, or off the right side of the canopy in a high g roll to the right), turn 180° through the vertical plane, under the enemy, relax g and dive for separation. To follow, the enemy must turn out of his nose-high yo-yo toward your six-o'clock position. This allows you to gain lateral separation and places the enemy in an overhead attack with a negative delta Mach.

Counter to High G Barrel - Roll Over the Top

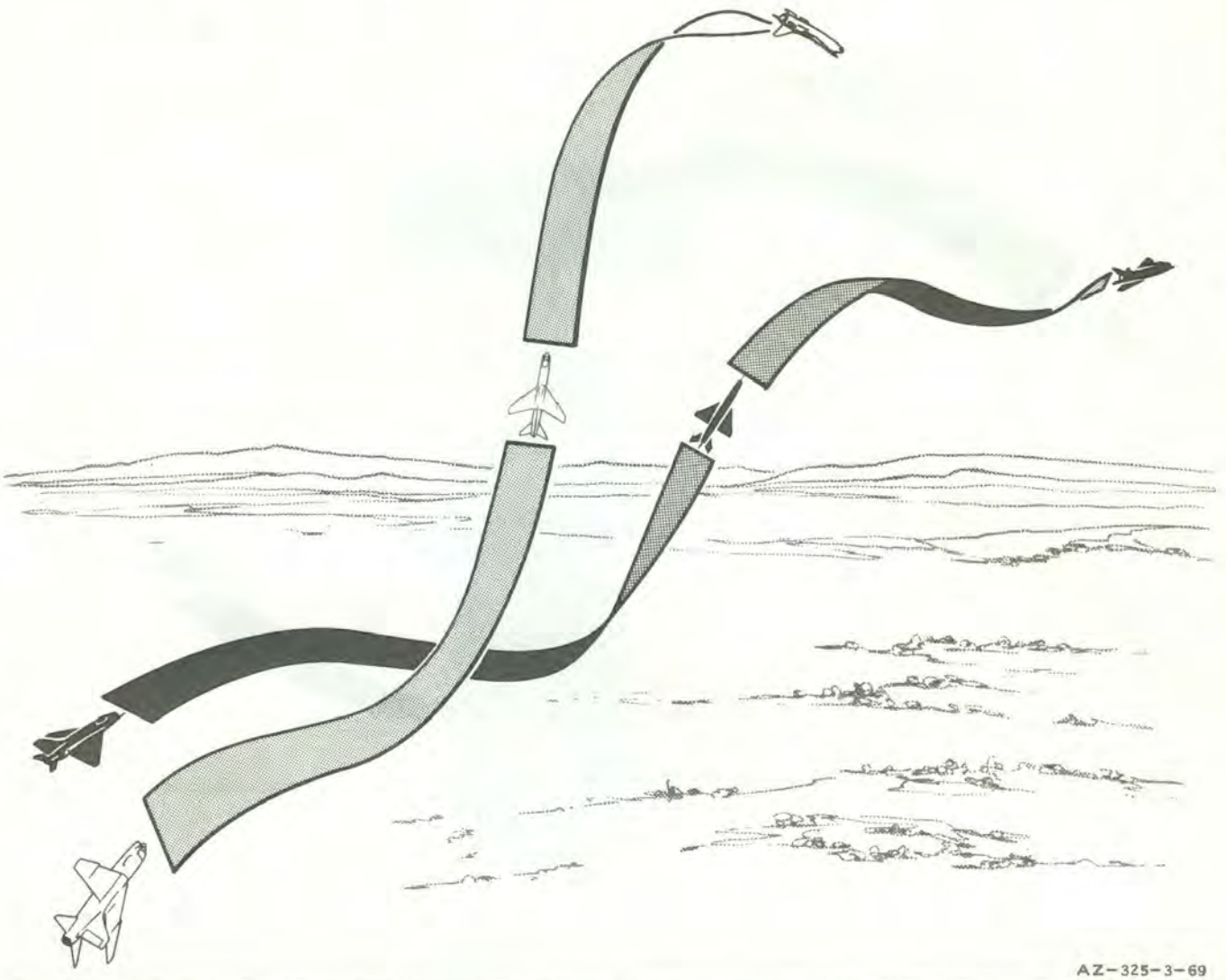


Figure 1–5G

THE HIGH G ROLL UNDERNEATH

In discussing the high g roll underneath (figure 1–5H), assume that you are in a defensive turn with an enemy at six-o'clock, inside gun firing range. If you do not have the necessary airspeed to execute a high g roll over the top, you are committed to a high g roll underneath. With these conditions prevailing, immediately start the high g roll underneath in an effort to shake the enemy. Do not delay. Otherwise you will experience considerable speed decay and will encounter considerable difficulty in executing the maneuver. To execute the roll underneath, maintain back pressure and employ rudder in the direction of the roll all the way around the roll. If done properly, the maneuver will describe a barrel-roll underneath. Just after the maneuver is started, it will appear as a split-S to the enemy. This illusion is created by the high angle of attack generated in performing the maneuver (this deception may cause the enemy to cut off in an attempt to counter your apparent dive for separation. The cutoff will place the enemy in a steep nose-down attitude). As you roll past the inverted, near-vertical position to a wings level and near nose-level attitude, the enemy will

High G Barrel-Roll Underneath

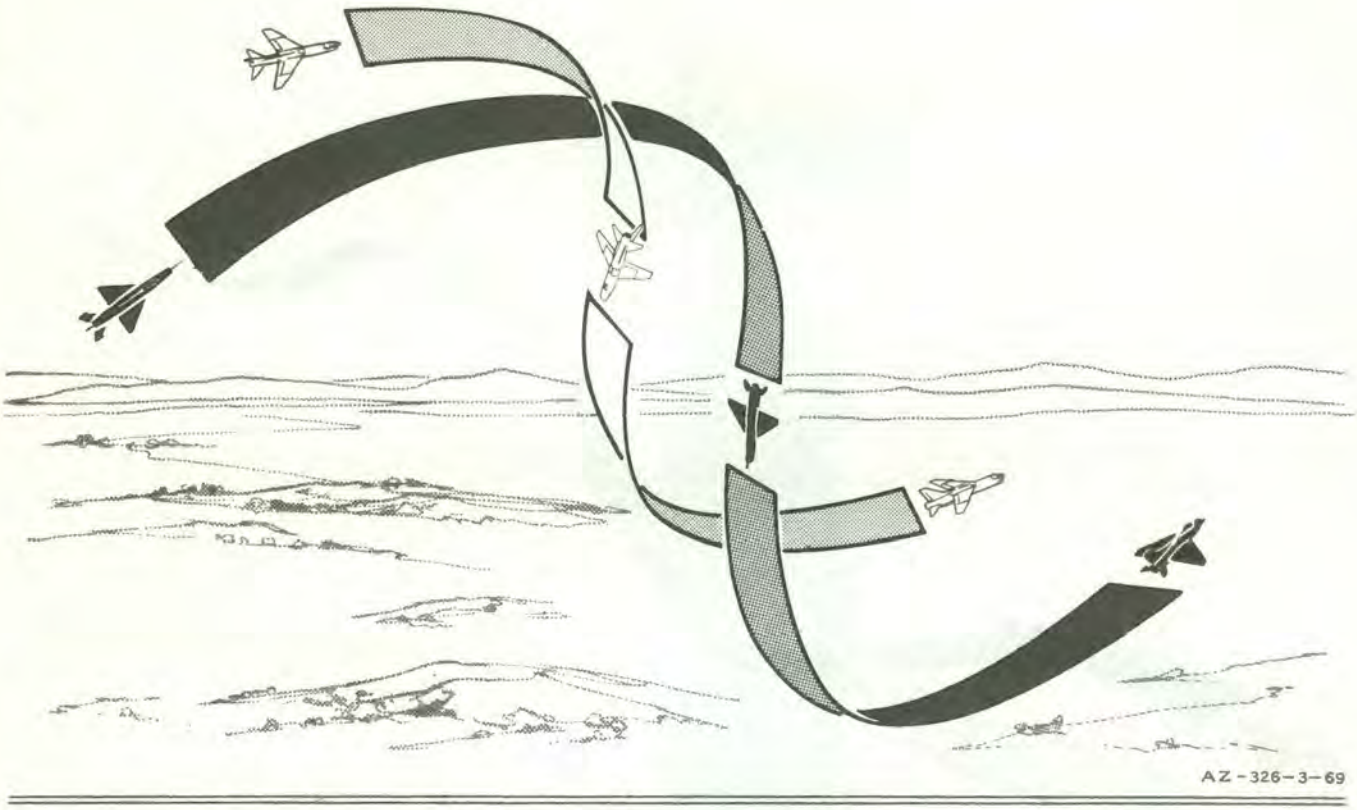


Figure 1–5H

overshoot below your line of flight at a higher relative airspeed. He is forced into the overshoot because his steep nose-down attitude combined with his rate of roll and/or turn (which depends upon your rate of roll and turn) forces him below you with a higher vector velocity along the axis of the high g roll. Upon completion of the maneuver, you will be above and somewhat to the rear of the enemy. To gain a firing position, roll-off of "S" down to his six-o'clock position.

To counter the high g roll underneath (figure 1–5J), it is obvious that the enemy must not generate a steep nose-low attitude and then attempt to follow the maneuver. In other words, he must not interpret the roll underneath as an apparent dive for separation. To determine whether the maneuver is a roll underneath or a dive for separation, he need only observe the dynamics of your initial move down and out of the defensive turn. If you appear to fly through his longitudinal axis, you are in a dive for separation. If you appear to pivot, or rotate, around the longitudinal axis, he should not cut off. Instead, he can pull up, delay momentarily, then follow you around the roll. This will provide him the opportunity to play the maneuver, hence prevent an overshoot below you. As a second alternative, the enemy can pull off and roll in the opposite direction. By doing this, he does not depend upon a g and rate of roll governed by your velocity, angle off, and range. Instead, he can pull the g necessary to play his rate of roll to reduce vector velocity and prevent an overshoot. If done properly, the reverse-roll will place him at your six-o'clock position. Upon completion of your roll underneath, you can maneuver against either one of these counters, by observing the enemy's actions.

Counter to High G Barrel-Roll Underneath

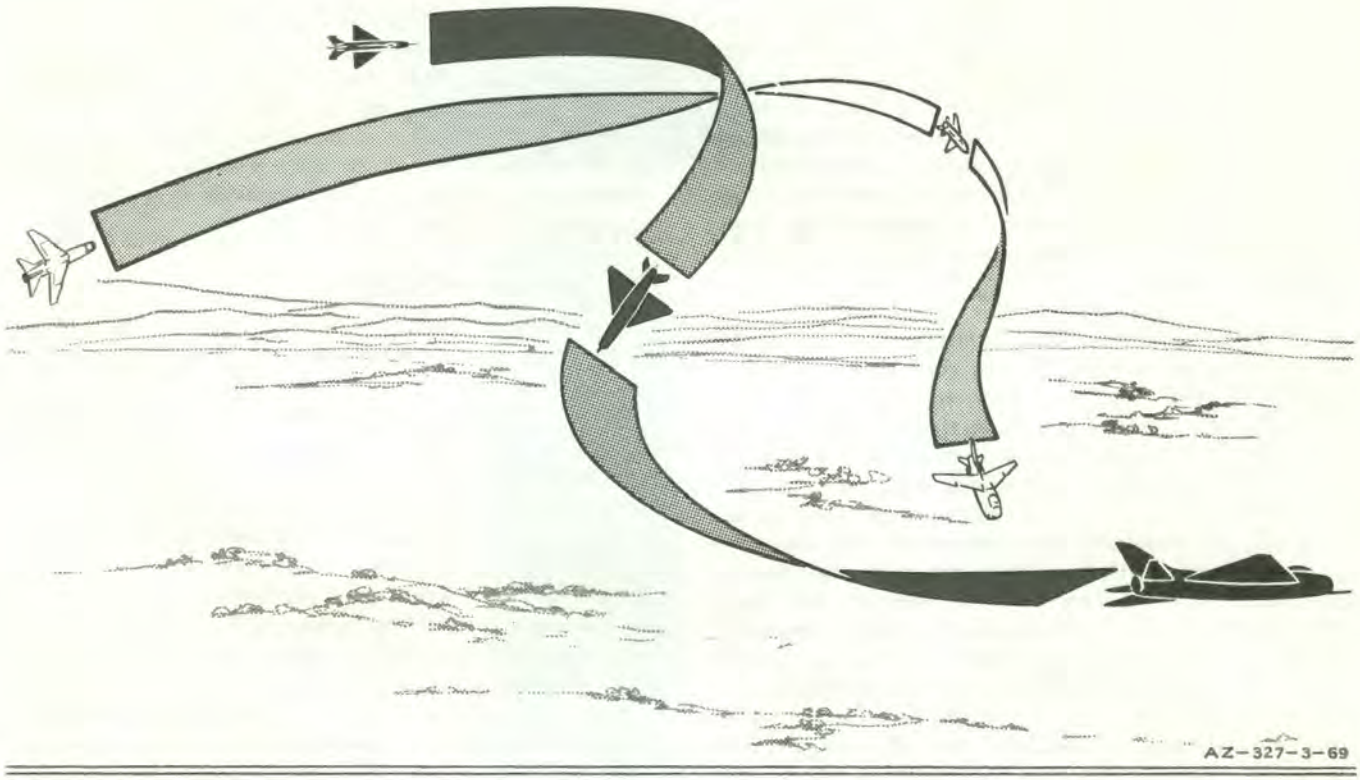


Figure 1-5J

If he pulls off to initiate either counter, do not complete the maneuver. Instead, relax g and dive for separation. If he is pulling off and up in either case, he will be forced into an overhead attack with a negative delta Mach. However, the separation gained in this situation is not as great as in the other overhead attacks with a negative delta Mach. Therefore, he can exert a great deal more pressure unless you can deceive him into following your high g barrel-roll underneath.

DEFENSIVE TURN

The purpose of the defensive turn is to prevent an enemy from achieving a firing position by rotating your angular velocity cone away from him. The best way to achieve this is to turn into the plane of the attack. This means that in an overhead attack, pull up into the attack; in an underside attack, dive into the attack; and if the attack is from six-o'clock, turn in

whichever direction provides the greatest tactical advantage. If you spot an enemy approaching your angular velocity cone from six-o'clock, perform a hard turn with a slight dive. This turn should not be a break or a maximum performance maneuver or you will experience high speed-decay and loss of maneuvering potential, which will eventually diminish your angular velocity. If you employ a hard turn with a slight dive, you generate enough angular velocity and at the same time retain future maneuvering potential. At long range, the rate of turn required for the enemy to track is considerably less than yours, since he is in a pursuit curve attack and his rate of turn is a function of target speed, angle-off and range. Consequently, his angle-off continues to increase as his range decreases. Remember, rate of turn increases as angle-off increases and range decreases on an attack against a maneuvering target. This means that the enemy generates a rapid buildup in his rate of turn.

Approaching gun range, the enemy will attempt to reduce his angle-off and slide into your six-o'clock position. To prevent this, you must increase g and rotate your angular velocity cone away from him. Your concern now is to acquire a smaller turn radius than the enemy. This will force him outside your turn and prevent him from achieving a tracking solution. To accomplish this objective, play the turn with respect to his position. The moment you notice his attempt to diminish angle-off, increase g to prevent him from doing so and sliding toward your six-o'clock position. If he continues to press the attack, tighten the turn to prevent him from staying on the inside of the turn. In effect, you are attempting to place him on the other side of your angular velocity cone. If you play this maneuver correctly, he will be unable to match your turn radius. The formula for turn radius:

$$R = \frac{Vf^2}{32.2N}$$

Where R = Turn radius in feet
Vf = Fighter velocity in feet/second
N = Number of radial g

This shows that the fighter with the lower velocity and/or greatest g has a smaller turn radius. In this situation, the enemy's speed and g are directly affected by your action. If you pull a certain number of g, he cannot pull the same amount. If he does, his rate of turn will equal yours and, at the end of a 180° turn, you will be behind him. Of course this will not occur, because the enemy will be forced to play his turn with respect to your position. This means that his g will be less, and as a result his speed decay will not be as rapid as yours. As is shown by the turn radius formula, the enemy will have a greater turn radius for two reasons: (1) higher speed, and (2) lower g. As a result, if he continues to press the attack in the plane of your turn, he must overshoot. This provides him with little opportunity to track and places him, geometrically, on the other side of your flight path. Of course, this presupposes that you are turning near or at maximum rate. If not, the enemy would be able to slide toward 6-o'clock, pull a higher g, diminish airspeed and avoid an overshoot. As will be discussed later, the lateral separation provided by this overshoot is a "must" for your subsequent actions.

THE SCISSORS MANEUVER

The scissors is a defensive maneuver in which a series of turn reversals is executed in an attempt to achieve offensive potential after an overshoot by the enemy. (The scissors maneuver is illustrated in figure 1–6.) To successfully employ the scissors, you need an initial turn overshoot. If you continue to turn in the same direction after the overshoot, the enemy will have the opportunity to maneuver toward your six-o'clock position, simply because you will be turning away from the attack. To prevent this, initiate a turn reversal as the enemy passes through your flight path. The decision as to when to execute this reversal will depend upon the enemy's rate of overshoot, his angle-off, and upon the type of aircraft. A good rule-of-thumb is: rapid turn overshoot, early reversal; slow turn overshoot, late reversal. The turn reversal will rotate your angular velocity cone away from the enemy. This will place him at a high angle-off and will cause him, once again, to cross your flight path. You have now forced him into a scissors maneuver.

Geometric inspection will show that the aircraft which has the shorter turn radius and the lower velocity will force the other to the 12-o'clock position. In this maneuver, you have the advantage. By virtue of forcing the enemy to overshoot, you have the lower velocity and if you employ the proper technique, the enemy can easily be placed at 12-o'clock. To accomplish this, each turn reversal should be a rudder reversal, at max-performance. If aileron is applied, you will be forced to release back-pressure to execute the reversal. This,

Scissors Maneuver

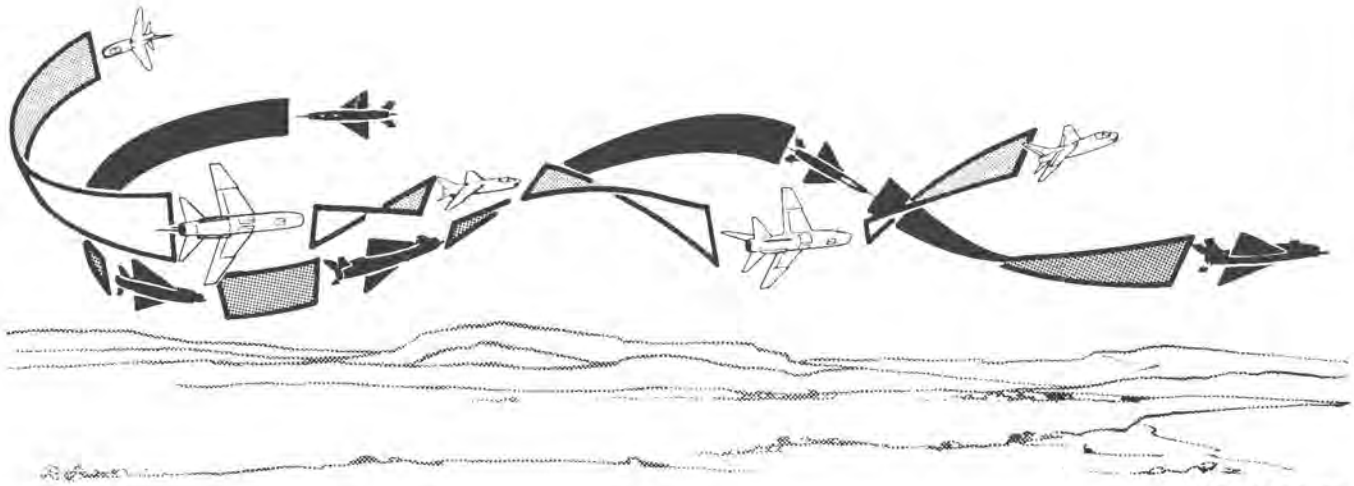


Figure 1–6 (C)

of course, will increase your turn radius. A nose-high attitude accomplishes two things: (1) It reduces your horizontal turning component, and (2) it reduces your vector velocity in the horizontal plane. The reduction in the horizontal turning component and vector velocity is a result of maneuvering through both the vertical and horizontal planes. You are employing the pull of one-g gravity to provide a greater radial g and a lower velocity. Use maximum power in this maneuver because its force vector opposes one-g gravity and is directed toward the inside of the turning circle. This provides you the opportunity to maneuver through the vertical plane, thereby diminishing your horizontal turning component. In addition, since power provides a lower stall speed, it permits a tighter turn radius at a given airspeed and reduces airspeed to the lowest possible. If you perform a nose-high rudder reversal with power on, your turn and velocity components are reduced to their smallest state and, if the enemy doesn't counter in like manner, he will be quickly forced to the 12-o'clock position.

If the enemy counters effectively and forces you below, maneuver in phase with him. This puts the enemy at a visual disadvantage since you will be directly beneath him. In an attempt to find you, the enemy will be forced to roll excessively in one direction or the other. This increases his stall speed and forces him forward and down toward your flight path. The moment the enemy notices this, he will probably reduce bank and maneuver as smoothly as you, with a resultant standoff. If and when this occurs, employ afterburner, relax g, and dive 180° away from him. Initiate this maneuver immediately after the enemy has made his last observation, when he does not have visual contact. In this way, you have the opportunity to gain considerable longitudinal separation and place him in an overhead attack with a negative delta Mach.

When employing the scissors maneuver, attempt to secure an advantage as quickly as possible, certainly by the second turn reversal. If you do not, you will lose airspeed rapidly and therefore maneuverability, and will never acquire an advantage. Instead, you will be in a standoff, with marginal control, and an easy set-up for another enemy aircraft. It should be noted that the F-8 cannot achieve an advantage over most Communist bloc fighters in a slow speed scissoring environment, either wing up or down.

COUNTERING THE SCISSORS MANEUVER

As previously stated, the scissors maneuver is a defensive maneuver designed to take advantage of an enemy's overshoot (figure 1–6A). Also discussed was the counter to use to gain this advantage. The implication is clear. A fighter pilot places himself in a very serious position if he misjudges and overshoots. If you are attacking, it is suggested that you employ the high yo-yo any time your rate of closure may cause a turn overshoot. In this manner, you can retain the offensive advantage. However, if you misjudge an enemy's turn and are forced into an overshoot, there is an effective counter to the scissors which shows that the scissors is highly overrated as an easy method to achieve an offensive advantage.

Counter to Scissors Maneuver

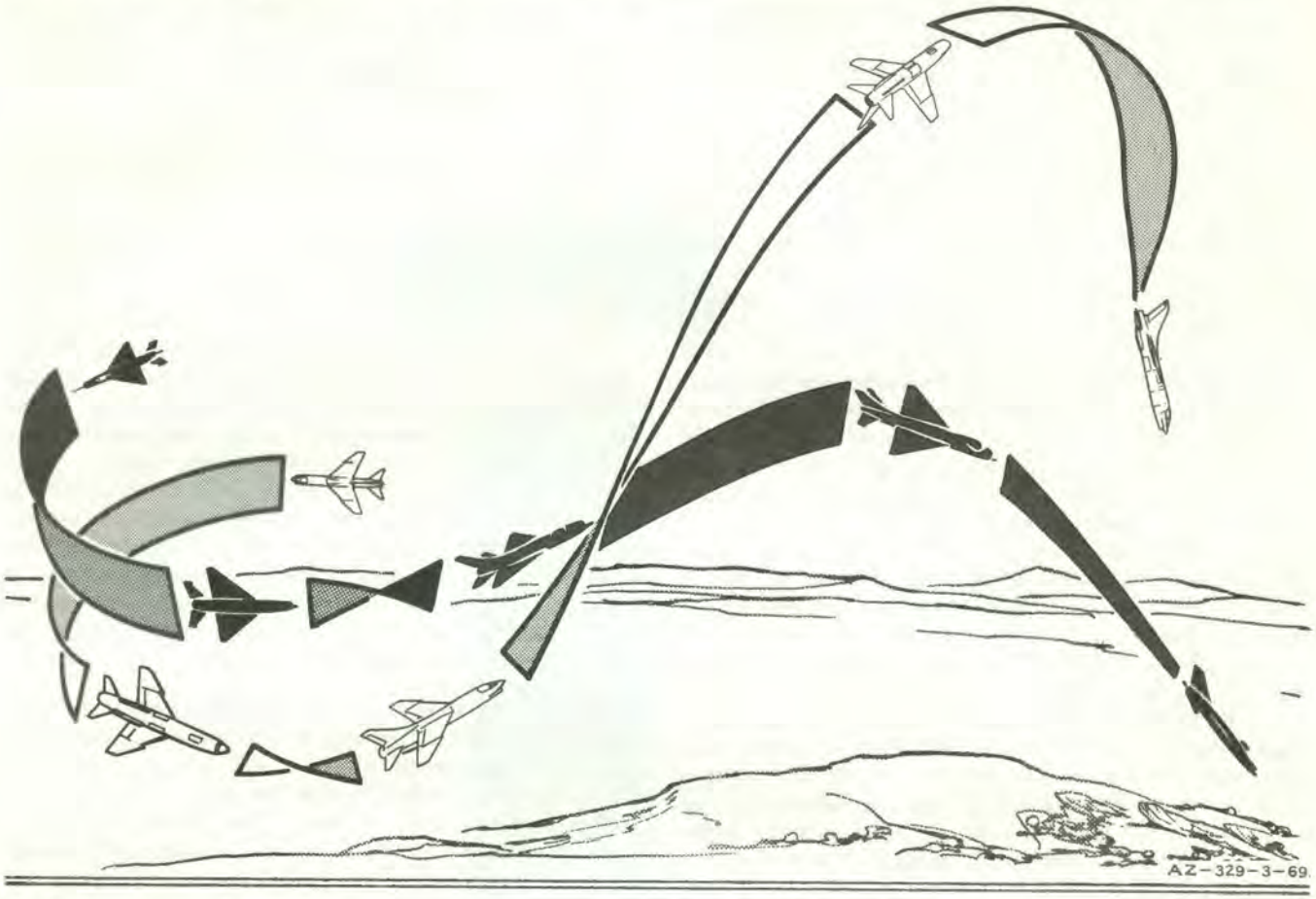


Figure 1–6A

To counter a scissors maneuver, determine your maneuvering potential with respect to the enemy. When attacking, you have a significant advantage in terms of velocity that can be converted to a tactical advantage if it is employed properly. Maneuvering into a nose-high scissors is not proper employment as this places you forward or above the enemy and in a stalemate. On the other hand, if you employ velocity in the vertical plane in a zoom maneuver, you can generate a significant advantage. As you realize you are overshooting the enemy's turn, relax g and deliberately slide around the outside of the turn. Relaxing g serves a twofold purpose: (1) maintains a speed advantage, and (2) increases lateral separation on the overshoot. This reduces your velocity component along the axis of the enemy's flight path, thus maintaining nose-tail separation. Observing the overshoot, the enemy will be enticed to execute a nose-high reversal in an attempt to gain offensive advantage. If he continues the turn, play the maneuver and, once again, slide into his angular velocity cone. In view of this, a reversal is almost a sure thing. As the enemy reverses, roll wings-level and zoom at the max-rotation-angle, through the vertical plane. The enemy will be unable to match your rotation angle and subsequent zoom because of his airspeed disadvantage. In this way, you can reduce horizontal vector velocity to a value smaller than the enemy's, even though you have a higher airspeed. As a result, you will be on top with nose-tail separation, and the enemy will have dissipated his airspeed, with a consequent loss of maneuvering potential. You need only roll off to his six-o'clock position.

If the enemy pulls up in a banked attitude toward your rotation, the height of his pullup will be even less. This is the result of two factors: (1) his pullup is only a component of a straight pullup — his rotation angle is through both the vertical and horizontal planes. His rotation angle in the vertical plane must be less than a straight pullup. (2) his stall speed is higher in a banked attitude. Higher stall speed causes the rotation component in the vertical plane to be even less. As a result of these two factors, his rotation angle is reduced. This means that the height of the zoom in

the vertical plane is less and vector velocity in the horizontal plane is increased. This forces him to turn below, in front of, and across your line of flight. You need only roll off in a direction opposite his turn and move toward the six-o'clock position. The rolloff increases nose-tail separation and prevents a possible overshoot.

To maneuver against your overshoot, the enemy simply cannot refuse to reverse and continue his defensive turn. If he does, you are not obligated to roll wings-level and zoom in the vertical plane. The enemy will turn away and place his angular velocity cone in front of your flight path. As a consequence, simply play his turn and maneuver toward the six-o'clock position. If the enemy cannot pull up and turn into, or away from your attack, he has another alternative. As you overshoot his turn, the enemy executes a nose-high reversal. This forces you to roll wings-level and zoom for altitude. If you fail to generate a large rotation, your vector velocity will be greater, and you will be forced toward the enemy's twelve-o'clock high position. So, you must rotate through a large vertical angle when the enemy executes his nose-high reversal to obtain considerable vertical displacement. Having placed you in this position, the enemy turns 180° in the vertical plane, relaxes g, lights afterburner, and dives for separation. (He must accomplish his turn before dissipating too much airspeed and acquiring an extremely nose-high attitude.) Noting the dive for separation, you must turn from an extreme nose-high position, 180° in the vertical plane to regain an offensive position at six-o'clock. The pull of one-g gravity causes you to dissipate considerable airspeed. Thus you are in an overhead attack with a negative delta Mach, outside of gun range.

Remember: The counter to the scissor maneuver is nothing more than a high yo-yo initiated after a turn overshoot. Relax g, roll wings-level and zoom in the vertical plane to retain or regain nose-tail separation.

HORIZONTAL ROLLING SCISSORS

A variation of the slow speed scissors just discussed is the horizontal, rolling, slow speed scissors. As the name implies, this type of scissors involves a series of barrel-rolls with the axis of the roll being in the horizontal plane. The rolling scissors is a more efficient defensive maneuver than the horizontal scissors due to the utilization of a three-dimensional maneuver (barrel-roll). The rolling scissors may be used in nearly all situations where a horizontal scissors could be used, the exception being the case in which the defender simply does not have enough speed to roll over the top (less than 250 KIAS in the F-8). The rolling scissors is most effective when the attacker overshoots with a high angle-off or overshoots below (underneath) the defender's flight path.

If you are being attacked, remember the rule of thumb: rapid overshoot, early reversal; slow overshoot, late reversal. As you reverse, maintain back stick pressure to attain the maximum g available and utilize the rudder as the primary control for rolling back into the enemy. As you pass through the wings-level position during the reversal, utilize any excess speed to zoom in the vertical plane, thereby further decreasing forward velocity vector. As the enemy is sighted on the opposite side, continue the roll into him, attempting to roll over the top of his aircraft. If he has continued his turn in the horizontal plane, his forward velocity vector will be greater than yours and he will be forced out in front. Do not allow him to roll toward your flight path. Keep him out of phase by rolling in the same direction that he does. Continue rolling until he is forced out in front. Once again, remember the control techniques of back stick, maximum rudder, and minimum aileron must be utilized.

A smart attacker will not allow himself to be trapped in a scissors. If you are attacking, do not dissipate your airspeed advantage by attempting to turn with the enemy when it is obvious that you will eventually overshoot. If you press too close, overshoot, and the enemy reverses, immediately level your wings and zoom in the vertical as the enemy attempts to roll into you. At this point the enemy should not attempt a scissors since your original airspeed advantage will allow you to rotate to a steeper attitude in the vertical plane and thereby decrease forward velocity vector to a component less than the enemy's. Once the enemy detects your pullup, he should turn 180° in the vertical plane and dive away in an escape maneuver. This will place you in an overhead attack with a negative delta Mach. It should be noted that the F-8 cannot achieve an advantage over most Communist bloc fighters in a slow speed scissoring environment, either wing up or down.

MANEUVERING FROM A FORWARD HEMISPHERE ATTACK

Many fighter-versus-fighter engagements start with the opposing fighters approaching each other's nose-quarter position. Since this is the case, fighter pilots must understand the tactics needed to gain an advantage from this position.

As previously stated in the concept of turn and velocity, there are only two basic things that can be done to gain an advantage — change direction (turn) and/or change velocity. As the attacker in a nose-quarter attack, you must maneuver into the angular velocity cone in the rear hemisphere of the enemy. This means that in a nose-quarter attack, you will need a substantial rate of turn, a small turn radius and a closing velocity to gain the enemy's six-o'clock position. If you fail to acquire these three factors, you may never gain an advantage. Worse yet, you may provide the enemy with the advantage. Assume that you are approaching an enemy from a nose-quarter position. The moment you visually acquire him, dive and light afterburner to gain an airspeed advantage. The distance you dive depends upon the aircraft's acceleration and zoom capabilities and your initial speed. The airspeed gained from this maneuver will provide you with a greater forthcoming zoom capability than if you maintain straight-and-level flight. The zoom permits freedom of maneuver in the vertical plane, so that you may effectively use the pull of gravity to increase rate of turn and to reduce turn radius along the horizontal axis. Another advantage acquired by the dive maneuver is the element of surprise. The dive frames the enemy against blue sky and frames you against the ground (assuming the opponent does not counter with a like maneuver). It is generally more difficult to maintain visual contact with an adversary framed against the ground, so the enemy may fail to maintain visual contact (especially at long range after the dive maneuver is executed). The possible lack of visual contact enables you to set up the next stage of your maneuver — a turn for an offset in the horizontal plane. If the enemy fails to maintain visual contact, as evidenced by a failure to turn, you can easily generate this offset.

Note

Do not attempt to gain lateral offset if the enemy has you in sight and his aircraft turning performance is superior to yours. Meet him with zero offset. Any offset will allow his superior turning performance to be used to your disadvantage.

If the enemy fails to counter, you will be below and off to one side of the enemy, on an anti-parallel course. With an airspeed advantage, you are now in position to execute a turn through the vertical and horizontal plane toward the rear hemisphere of the enemy. Since you are below him, you may start the maneuver before reaching a line-abreast position. Execute a chandelle-type maneuver toward the enemy. The chandelle diminishes airspeed and reduces horizontal turn radius. This will prevent an overshoot; however, it will diminish closing velocity as you approach the enemy's rear hemisphere. To prevent the enemy from achieving considerable longitudinal separation, turn down through the vertical plane (low yo-yo) toward his six-o'clock-low position. The turn down through the vertical plane enables you to effectively use the pull of gravity to achieve an increase in airspeed and turn rate. If the enemy fails to counter, you need only drive in underneath him and set up for an attack.

To effectively counter a nose-quarter attack of this nature, the enemy should push over and dive for separation as you attempt to zoom, turn, and dive for a six-o'clock position. This maneuver will place you in an overhead attack with a negative delta Mach, with extreme longitudinal separation, and it will be difficult to close for an attack.

In many cases an enemy will be met head-on with little or no lateral offset. This is particularly true when both aircraft sight each other at long range, turn into each other, and both attempt to gain an advantage prior to meeting. When meeting under these conditions, the pilot of each aircraft has four basic choices of action: turn nose high, nose level, nose low, or continue his present flight path. There is no single best course of action. The professional fighter pilot will choose a course of action that best suits the particular engagement, taking into account the following parameters: altitude spectrum involved; energy level of both aircraft; turning performance of both aircraft; acceleration capabilities (thrust to weight ratio) of both aircraft; visibility restrictions of both aircraft; and position of the sun or other factors affecting visibility.

A nose-high turn, as previously discussed, will produce an increased rate of turn and decreased horizontal turn radius as the aircraft is turned from a nose-high to a nose-low attitude. However, during the initial pullup, turn rate will be relatively low and horizontal turn radius relatively high. The overall advantage of a nose-high turn (essentially a high yo-yo) is the decreased horizontal turn radius and the maneuvering potential that is rapidly gained during the second part of the turn (essentially a low yo-yo). Caution must be exercised during the pullup. Do not allow airspeed to decay to the extent that maneuvering potential is lost. Ideally, a minimum airspeed of 350 KIAS should be adhered to during a nose-high turn; but, practically, lower airspeeds will be prevalent in the F-8 (particularly at high altitude). From this discussion it can

be seen that a nose-high turn at high altitude may not be possible and/or desirable. Maneuvering potential will be lost if the necessary nose-high attitude is used and horizontal turn radius will not be significantly decreased if airspeed and maneuvering potential are maintained by using a shallower attitude.

A level turn will allow a rapid 180° heading reversal but is characterized by a large horizontal turn radius and/or a large decay in airspeed and maneuvering potential. At high altitude an unacceptably large turn radius may result if maneuvering potential is maintained throughout the turn and an unacceptable loss in maneuvering potential may result if turn radius is decreased by increasing g. A level turn may be desirable when at a relatively low altitude and the aircraft is at an extremely high energy level (500 KIAS or greater). In this case the decay in airspeed is traded for a gain in angular advantage; airspeed will still be high due to the initial speed and large amount of power available at this speed and altitude.

A nose-low turn will produce an increased turn radius since the force of gravity is acting in the direction of the turn, but provides an increase in airspeed and maneuvering potential. At high altitude it may be desirable and/or necessary to sacrifice altitude to gain maneuvering airspeed. Potential energy (altitude) is an important factor prior to an engagement; but once engaged, the most important consideration is kinetic energy (velocity) since this determines maneuverability. As the nose is lowered use care to keep the aircraft out of heavy buffet. Allow it to accelerate while maintaining as high a rate of turn as possible. When the desired speed and g are attained, commence a rolling pullup, being careful to preserve speed for the subsequent zoom back to the opponent's altitude. During this maneuver, nose-down attitudes of 45° to 60° are not uncommon, but do not exceed 60°. A split-S will produce an excessive turn radius. By turning and rolling when nose low, the horizontal turn radius will be held to an acceptable value and a tremendous increase in maneuvering potential will be realized. An additional advantage will be gained if the enemy turns level or nose high. It will be very easy for you to keep him in sight (framed against the sky) and very difficult for him to keep you in sight (framed against the ground or water). Low altitude may preclude or modify a nose-low turn. If limit g is already available, do not dive down into an enemy who is below you. You will unnecessarily increase your turn radius and give your opponent an angular advantage if he turns level or nose high.

The final alternative when meeting head-on is to continue your existing flight path. This is the obvious course of action if you do not desire to engage, but should also be used if your aircraft is not at the desired energy level. If the enemy has already started his nose up in a nose-high heading reversal when you meet and/or you do not have the desired airspeed, continue straight ahead. This will place him in an overhead attack with a negative delta Mach and a large nose-to-tail separation. Ideally you should reach your best maneuvering speed and start the nose up as the enemy is nose low and just starting to accelerate. As in any overhead attack with a negative delta Mach, if the enemy tries to follow the zoom in the vertical plane he will be unable to rotate to as high a nose attitude and will be thrown out in front in a vertical overshoot. Continuing straight ahead is also very effective to gain the desired separation if the enemy has superior turning performance. The extra separation provides the extra time necessary for you to reverse your heading (relative to his elapsed time for a heading reversal) and ensures a subsequent head-on meeting.

ESCAPE MANEUVER

In the preceding discussion of fighter versus fighter tactics, many situations have arisen where it was necessary to dive for separation placing the opponent in an overhead attack with a negative delta Mach. This is the escape maneuver. An escape will normally be made by an aircraft that is on the defensive, but may be made by an attacker who has lost his advantage due to a tactical error or who must disengage due to low fuel state, expenditure of all ammunition, necessity to protect a strike group, or a multitude of other considerations.

To properly employ an escape maneuver you must strive to initiate the maneuver when the enemy does not have you in sight. An example would be during a scissors when crossing below his flight path. Initiate the escape prior to his acquisition of your aircraft on the other side of his flight path. After carefully choosing the time to initiate the escape, turn so as to align your fuselage as nearly as possible with his, but headed in the opposite direction. The classic example would be to meet the enemy head-on and simply continue your direction of flight. Whether nose low, level, or high, the object is to force the enemy to make a 180° turn before he can commence pursuit.

As the escape is initiated, select CRT and at completion of the initial turn (to commence the escape), retract the droop. This will decrease drag and allow a

faster rate of acceleration. If not already in a nose-low attitude, commence a –0.5g pushover. Maintain a slight turn to keep the enemy in sight as he pursues. If he is still within lethal range, jinking maneuvers will greatly complicate his fire control solution and, properly timed, will preclude a lethal burst. Do not make these maneuvers so severe that you stop your acceleration. A break turn should foil any missile shot, but you *must* have the enemy in sight to see the missile launch.

Once beyond lethal range a reengagement may be possible if desired. Carefully consider the following factors prior to reengaging: the enemy aircraft type, the enemy pilot's abilities, your fuel and ammunition remaining, and all the other factors listed under ENGAGEMENT CONSIDERATIONS and TACTICAL CONSIDERATIONS.

COMBAT SPREAD PATROLLING FORMATION

DEFINITION

The combat spread is a patrolling formation. See figure 1–7. The formation is flat and wide, making use of the best lookout capability, formation flexibility, and mutual cover. The recommended distance abeam is predicated primarily on the restricted aft visibility from the aircraft. For the F-8, a minimum of 3/4 nautical mile to a maximum of 1 1/4 nautical miles is recommended. (Air-to-air TACAN may be utilized to determine proper distance.) This places the mutual blind area sufficiently aft to enable the detection of attackers at or near AIM-9B missile R_{max}. At the higher altitudes, the increased distance abeam creates a deficiency in mutual cover potential in terms of a gun attack. However, the deficiency is short-lived since:

a. If an enemy aircraft is sighted, the subsequent loose deuce maneuver for offensive position allows the team to reduce lateral displacement and achieve mutual cover, while the mutual blind area is reduced or eliminated as a result of the maneuvers.

b. If a missile defensive turn is performed, the attacker is forced to convert to a gun attack, allowing the team to reduce lateral displacement for mutual cover in subsequent defensive and offensive gun attack maneuvering.

The wingman is allowed some vertical leeway, increasing to 2,000 feet at high altitude, for airspeed adjustment in maintaining the abeam position. While a flat position is preferred, maintaining the abeam position is of primary importance. The two teammates have no tactical advantage over one another, and consequently no disadvantages. This poses an additional problem to any would-be attacker.

Lookout responsibility is simple: each pilot scans 100 percent of the area just as if he were solo. The mutual blind area shown in figure 1–7 can be cut down or eliminated periodically by slight, in-place, wing dip maneuvers to search toward six o'clock; that is, a seven o'clock scan should be accompanied by a left bank. However, speed and altitude must not be sacrificed by excessive maneuvering.

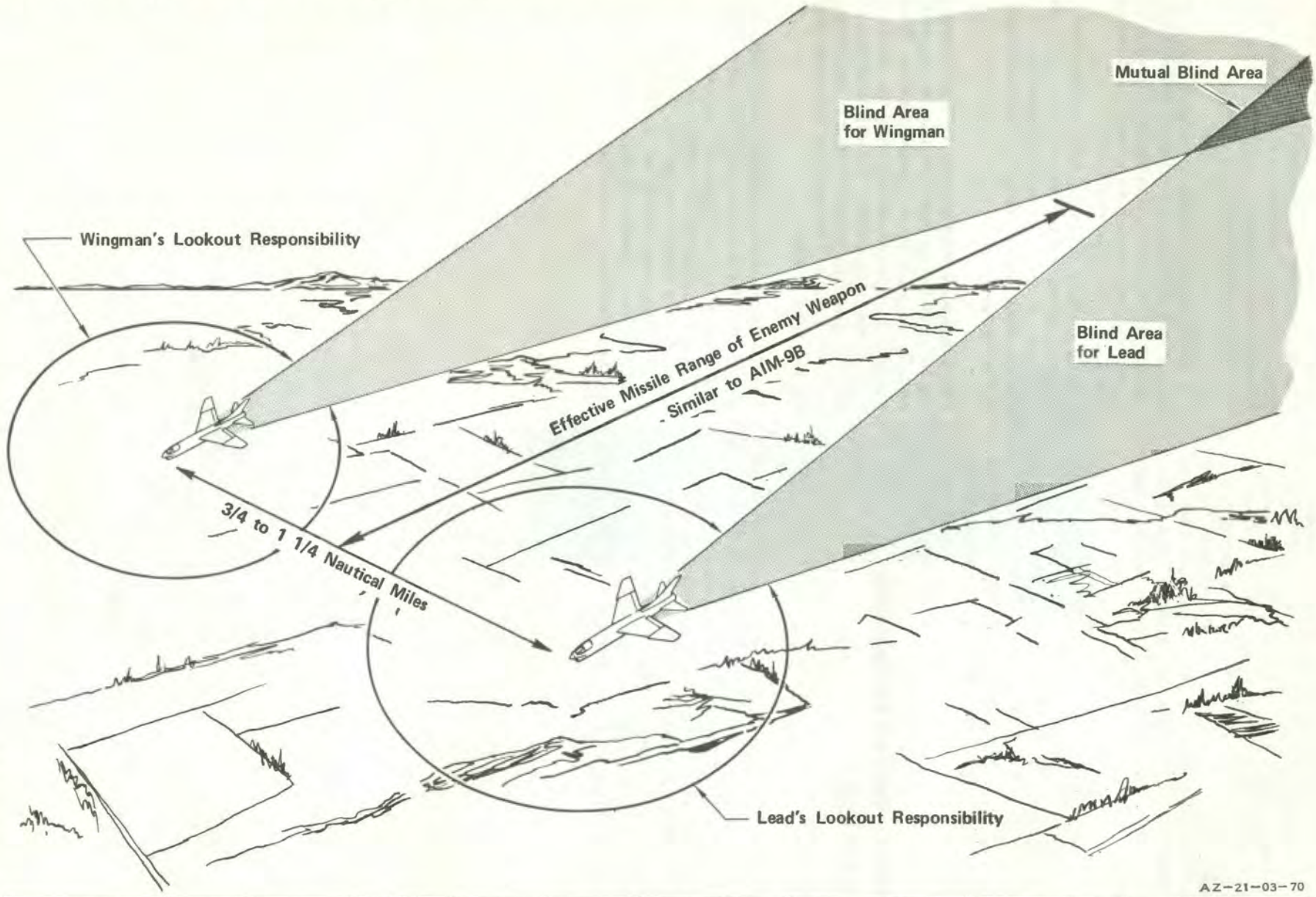


Figure 1-7 (C)(Gp-4)

CALLED TURNS

Called turns are used primarily in formation training and for general cruise course changes. They enable the wingman to plan his turn so as to arrive abeam the leader on a predetermined heading with a minimum of speed variation. For called turns into a wingman (figure 1–8), the wingman will turn so that after 45 degrees of turn by the leader, he will pass approximately 1 mile ahead and 1,000 feet above the leader, on a heading within 20 degrees of that of the leader. The initial angle of bank required of the wingman will vary from no angle of bank at wide distances abeam at high altitudes to an angle of bank slightly greater than the lead aircraft at close distances abeam at low altitude. As the wingman crosses in front of the leader, he should increase his lookout scan in the rear hemisphere of the leader. He will drift outside the turn descending to base altitude to arrive at the abeam position after 90 degrees of turn.

For called turns away from the wingman or when a turn into the wingman is continued past 90 degrees for 180 degrees of heading change (see figure 1–8), the wingman will low yo-yo to the inside of the turn so as to pass approximately 1 mile aft, slightly low, accelerating and within 20 degrees of the leader's heading as the leader passes 45 degrees of turn. As the wingman passes aft of the leader, he should tend to concentrate more of his lookout scan to the aft hemisphere momentarily. The wingman then eases up and out to the abeam position as the leader rolls out on new heading.

UNCALLED TURNS

Uncalled turns (figure 1–9) demand that the wingman maneuver immediately in such a manner that he can adjust to the correct tactical position whenever the leader rolls out. All turns are done in yo-yo fashion by the wingman, mildly for gentle turns and steeper for harder turns. The wingman always maneuvers relative to the leader while patrolling.

An uncalled turn into the wingman is a much more pronounced yo-yo type turn than the relatively flat called turn. The wingman executes a high yo-yo so as to pass approximately 2,000 feet ahead of the leader with a significant altitude advantage.

As the leader goes out of sight under the fuselage, the wingman hesitates momentarily, then increases his angle of bank without increasing g so as to visually reacquire the leader on the inside of the turn on parallel headings. As the leader continues the turn, the wingman stays slightly to the outside while drifting aft in bearing abeam the leader at a distance of 1,500 to 3,000 feet. As the wingman approaches abeam, he will increase his angle of bank, lower his nose slightly to accelerate, while low yo-yo-ing to the inside of the turn, passing below and approximately 2,000 feet aft of the leader. The low yo-yo is continued to the inside abeam position. The wingman continues this cycle without reference to a roll out heading but always in a position to reassume the combat spread position from any point in the cycle in minimum time while maintaining a good scan pattern for mutual protection. The leader should hold a turn away for at least 60 degrees.

Uncalled turns away from the wingman are very similar to the called turn. The wingman must observe the turn as it is initiated and expedite closing to the leader's radius of turn by utilizing a slightly greater angle of bank. As he passes the leader's six o'clock position at approximately 3,000 to 4,000 feet aft, he reduces angle of bank to match the leader's angle of bank and continues the low yo-yo to the inside. If the turn is continued as he approaches the abeam position, maneuvering is continued as in the uncalled turn into the wingman.

Note

The yo-yo type maneuvering employed in uncalled turns allows the wingman to move rapidly out to the combat spread position as the leader levels his wings.

Yo-yo maneuvers during cruise turns should be very mild, increasing in severity as the turns become tighter. At altitudes above 40,000 feet, subsonic maneuvers must be very gentle. A pilot should never slide to the outside without an altitude advantage. When supersonic, maneuvers can be done more sharply but they must be done precisely.

The most important factor affecting the mutual support capability of the combat spread formation is the ABEAM POSITION. If tactically feasible, it is better to turn slightly to place the wingman on the beam rather than cruise while out of formation. The wingman should endeavor to roll out of all turns with some vertical advantage to exchange for position adjustment if needed.

If either member rolls out considerably ahead of his teammate and with more than normal altitude advantage, he should utilize the excess potential for a clearing turn across the top of the other member to an abeam position on the opposite side. It is necessary

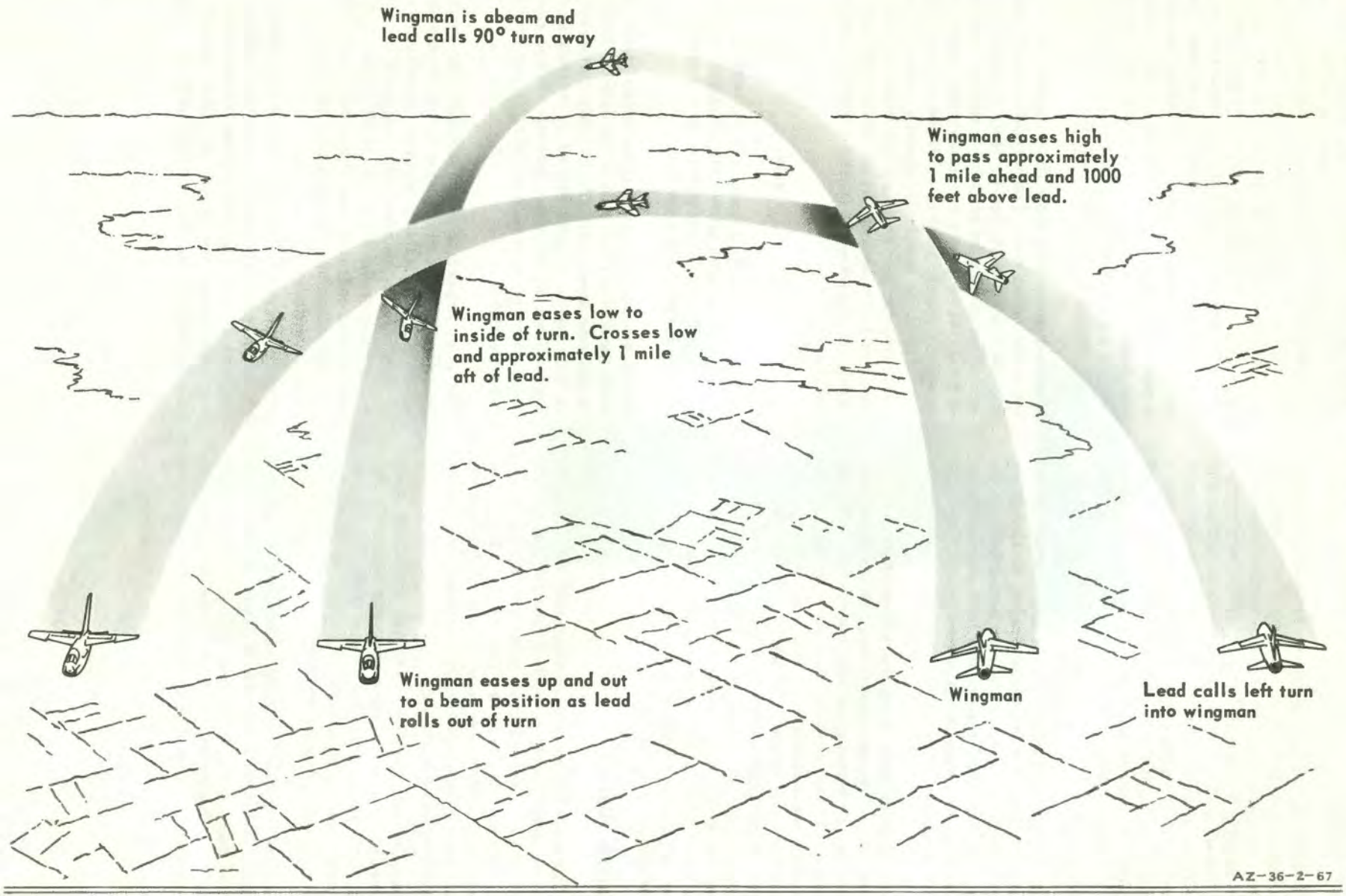

Wingman is abeam and lead calls 90° turn away
Wingman eases high to pass approximately 1 mile ahead and 1000 feet above lead.
Wingman eases low to inside of turn. Crosses low and approximately 1 mile aft of lead.
Wingman eases up and out to a beam position as lead rolls out of turn
Wingman
Lead calls left turn into wingman
AZ-36-2-67

Figure 1-8

Uncalled Turns Away From and Into Wingman

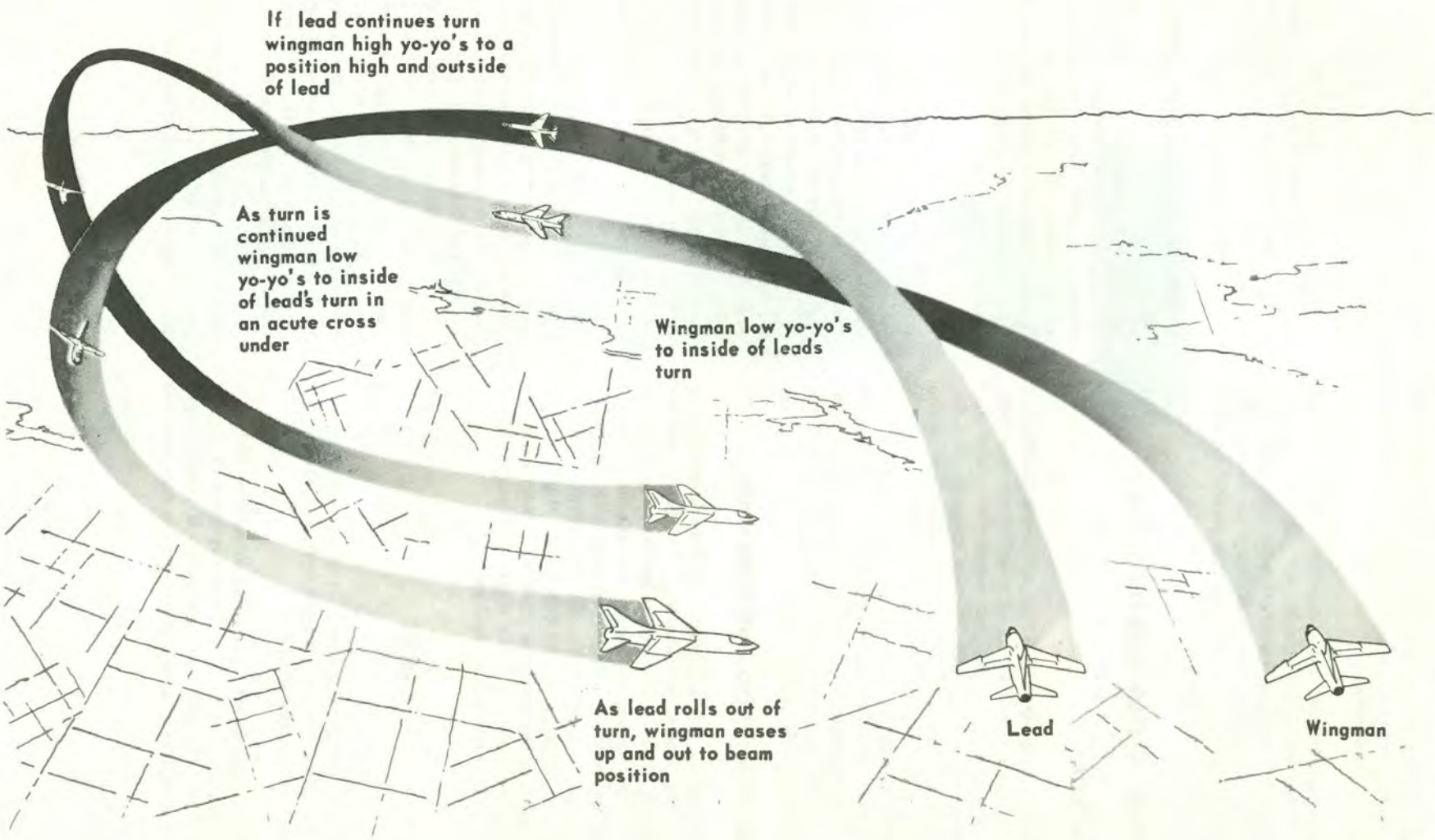


Figure 1–9

to preface such a turn with a call of "Positioning" so that the other member will not mistake the maneuver for an uncalled turn.

The three-dimensional maneuvering utilized in the combat spread formation enables the partners to cruise and maneuver without concentrating on formation flying. They can both maintain lookout for the enemy. An occasional glance at one's partner should be sufficient to maintain integrity.

TACTICAL WING FORMATION

INTRODUCTION

Loose deuce maneuvering is the optimum method of employing the F-8 section in air combat maneuvering and, as such, must be utilized whenever leader and wingman proficiency permit. Section integrity is, however, difficult to maintain utilizing loose deuce in the low altitude, high speed, high g environment and tactical wing formation may be required, particularly with a lesser experienced wingman. The section in tactical wing becomes much harder to separate, but as a result of the necessary compromise, has its lookout capabilities seriously degraded.

TACTICAL WING PATROLLING FORMATION

When patrolling, the wingman positions himself 45 to 60° aft of the abeam position and out about 1,000 to 1,500 feet. A slight step-down is necessary in order to facilitate free cruising on turns. The leader is free to maneuver as necessary while responsibility for maintaining position rests with the wingman. Primary lookout responsibility is the job of the flight leader. The wingman lends lookout assistance commensurate with his experience and the degree of attention he must devote to maintaining position.

Note

Lookout can be enhanced in escort missions by assigning section lookout coverage to elements of the strike group.

To maintain position the wingman maneuvers through both the vertical and horizontal planes using the plane of the leader's aircraft as a reference. If a turn away from the wingman is made, he lowers his nose slightly and crosses to the inside. If on the inside and sliding forward on bearing, the wingman crosses to the outside, slides high if necessary, and flies in the plane of the leader. This technique will cause the wingman to describe a circular movement in the plane of the lead aircraft and enable him to maintain position with little or no power adjustment. An occasional wing dip will increase the wingman's visual coverage of the six-o'clock-low position.

ENGAGING IN TACTICAL WING FORMATION

The fighting position is essentially the same as the patrolling position with this exception: the wingman maneuvers in a 60° cone on the leader's aircraft (60° aft of the beam, 30° off the astern position). Distance between aircraft remains the same, 1,000 to 1,500 feet. The technique for maintaining position is the same as when patrolling.

As soon as unidentified aircraft are sighted and an attack or defensive turn is initiated, the wingman slides to the edge of the 60° maximum performance cone. He must remain in this cone and match the maneuvering of the leader by cutting off, crossing, sliding to trail — doing whatever is necessary to stay with his leader. Occasionally during extreme maneuvering it will be necessary for the wingman to momentarily slide to the trail position. Attempt to cut the in-trail time to a minimum by sliding back to the edge of the 60° cone as soon as the leader eases some g. When possible, the wingman should zig-zag within the cone to increase his aft lookout capability.

The leader is the shooter and the wingman's responsibilities are very clearly defined: (1) to fly his aircraft in such a way that, regardless of the leader's maneuvers, he will not become separated; (2) to look around when possible (do not degrade primarily responsibility–maintaining position) and inform the leader of what he sees; and (3) maintain his missiles and guns ready to bear on a two or more element enemy or back-up the flight leader's ordnance. When the flight leader is pressing the AIM-9D minimum range boundary, timely consideration should be given to designating the wingman as shooter. His range and lateral separation could yield a superior set of Sidewinder launch conditions, figure 1–10.

When the F-8 section is attacked, the wingman must intensify his effort to remain in position. If he stays aft of bearing or separates too much laterally, he is

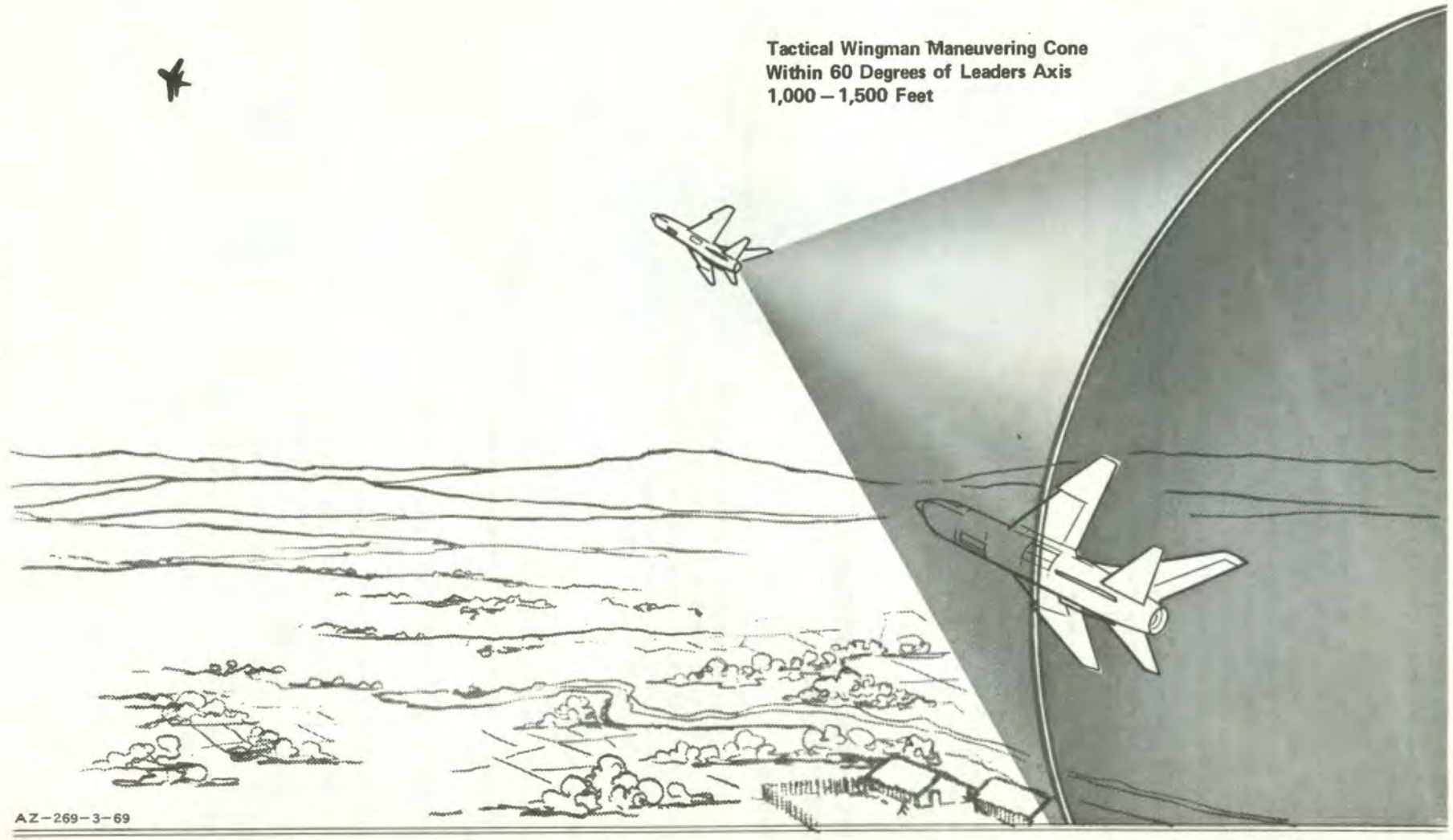

Tactical Wingman Maneuvering Cone
Within 60 Degrees of Leaders Axis
1,000 – 1,500 Feet
AZ–269–3–69

Figure 1–10

increasing the danger to which he is exposed. The wingman must be up close enough to his leader to make it necessary for an enemy aircraft to actually outmaneuver and outperform the leader in order to shoot down the wingman. A serious disadvantage of the defensive tactical wing is that the enemy is presented with only one target. The instant the enemy starts to gain, the section that is not capable of loose deuce maneuvering must disengage. The section able to split vertically by employing loose deuce presents two targets to the attacker and, in many cases, this may be the only way to shift from defense to team offense. When the leader splits the tactical wing formation, he must call the direction of turn for the wingman and, in most cases, his second turn as well.

Note

Upon entering loose deuce from tactical wing, it will normally take two turns (example: a low and a high yo-yo) before the wingman is able to grasp the overall tactical situation and the position of all aircraft in the engagement.

LOOSE DEUCE TACTICAL MANEUVERING

DEFINITION

The term "loose deuce" implies a flexible two-element tactical team working together in a tactical situation. This team can begin loose deuce tactical maneuvering from any initial position relative to each other. It is most generally entered from the combat spread formation or tactical wing.

TEAM INTEGRITY

Unit integrity means three things:

a. Knowing the position of your teammate at all times

b. Maintaining a position advantageous to his defense

c. Maintaining team offensive potential

An important principle in loose deuce tactics is that the tactical lead may be passed to the teammate who sights a target at long range. In many instances, enemy targets are picked up at great ranges and continuation of normal lookout scan would result in loss of contact. The member who sights the enemy gives the Talley-Ho report and then calls "PADLOCKED" if he would lose sight by continuing to fly formation. The member who Padlocks is given the tactical lead and the other teammate takes over the scan for the team. When both teammates spot the enemy, the military leader of the flight calls the play. During the ensuing engagement, the tactical lead changes from one teammate to the other as their positions in the engagement change. Generally, the teammate in the position to see most clearly the overall tactical picture has the tactical lead — he makes tactical decisions and "calls the shots." He must at the same time function as a wingman by maneuvering his aircraft with respect to and in support of his teammate. The pilot in the final phase of the attack (tracking or firing) is generally not the tactical leader due to his required concentration on the immediate situation.

Note

The military leader of a section always remains the same. The wingman may make tactical decisions during loose deuce maneuvering but is never relieved of his responsibility to support his leader.

HARD TURNS

The normal method of entry into loose deuce tactical maneuvering is the hard turn. The hard turn (figure 1–11) is a called maneuver utilizing MRT or CRT power with the power requirement and direction of the turn dictated by the teammate calling the maneuver; for example, "PIRATE, HARD STARBOARD, UNDER, BOGEY, FOUR O'CLOCK, RIGHT LOW, CLOSING." (If CRT is desired, the call should be "HARD STARBOARD, GATE.") The teammate on the inside of the turn, with sufficient airspeed/Mach, selects MRT/CRT power and starts a turn utilizing an angle of bank and g as necessary to place himself 2,000 to 4,000 feet above and 1,000 to 2,000 feet outboard of his teammate with his fuselage nearly aligned after about 100 degrees of turn. If the inside aircraft is below 450 IAS/0.9 IMN, whichever is lower, he may want to initially lower his nose in the turn to accelerate to maneuvering airspeed/Mach. With sufficient energy he can then slide high to the outside of the turn as previously described. The teammate on the outside of the turn will select MRT/CRT power and begin a minimum radius turn in a low yo-yo type maneuver to maintain airspeed /Mach. As he passes 6 o'clock of his teammate, he must advise him of his relative position and the enemy's movement if appropriate. The position of the enemy will dictate whether the initial turn is made nose high, level, or nose low. When the teammate who was originally on the inside of the turn reaches the high,

Cover Station and Hard Turn Technique

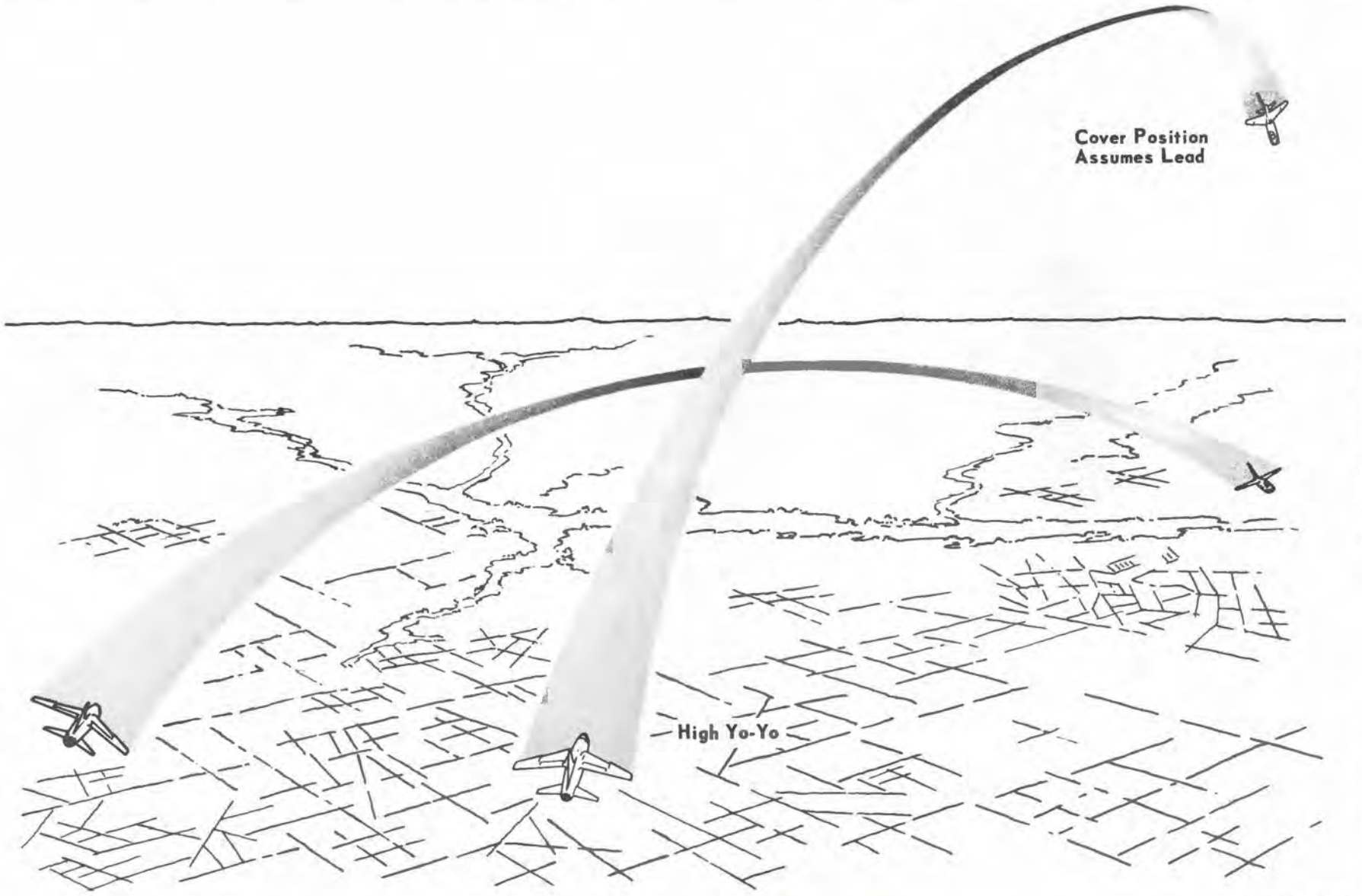


Figure 1–11

outside position, he is then at the cover position. As the high teammate starts drifting aft of abeam, he advises the low man that he is starting a low yo-yo so the low man can start a high yo-yo. Momentarily, the flight is level and in trail as the positions are switched. The high man will pass aft of the low man with the distance aft being a function of rate of turn, airspeed, vertical separation and, of course, the tactical requirements. As the trail man passes aft, he should advise his teammate of his relative position and the immediate tactical situation; for example, "CACTUS PASSING SIX. Bogey is switching to me. I'm starting down." The positions of high and low man are then continually switched by the use of high and low yo-yo's.

The main point to remember on hard turns is that the cover positions must be taken by the man who is in a position affording the best total engagement picture. The team will spread more vertically than horizontally. Each aircraft will be in a steep bank and visibility will be excellent toward the inside of the turn. However, for the short interval of the turn, visibility to the outside of the turn will be poor; the teammate going from the low position to the high position must scan aft momentarily as he relaxes his bank initially for the high yo-yo. Vertical separations of 3,000 feet to 6,000 feet are not uncommon. As shown in the illustrations covering offensive and defensive maneuvers, utilization of this yo-yo technique allows the team to keep an enemy turning while maintaining the team's speed. On the defensive, any enemy attacking one teammate will have that teammate's partner above and behind him setting up a "sandwich" after approximately 90 to 180 degrees of turn.

The teamwork training gained in loose deuce tactics gives the team many advantages which are not available to pilots unaccustomed to wide separation maneuvers. Switching for better target angles, offensive feints, etc, comes naturally in complicated engagements. Killing off airspeed to track is not necessary, and a defensive break should never be needed. This team has the best flight integrity of any tactical formation.

The covering pilot should never be closer than 1,000 feet to his teammate, and should only be passing through his altitude. He should not try to follow small area maneuvers such as high g barrel-rolls, scissors, etc. He must visualize the overall maneuver area and take the station most advantageous to his teammate's defense.

The hard turn can also be an in-place turn (figure 1–12) used for a near reciprocal course change, for example, when an enemy is sighted far enough out so that a near head-on encounter can be made. It is a maximum performance, MRT/CRT turn and MUST BE CALLED. Both aircraft come around hard with neither pilot attempting to gain altitude or airspeed potential on the other. After about 90 degrees of turn, the team will be momentarily in trail. Lookout capability is nearly perfect on the inside of the turn and the previous blind area comes quickly into view. This turn can be combined with low or high yo-yo's to change altitude or maintain airspeed as the situation dictates. The trailing teammate must match the turn and the yo-yo of the other aircraft. As the teammate passes six o'clock of the lead aircraft he transmits "ACE to the inside." The lead aircraft acknowledges and assumes flight integrity responsibility when he visually acquires his teammate. This procedure is repeated for each 180 degrees of turn.

VERTICAL REVERSE TURNS

The vertical reverse turn is generally used to force a shadowing enemy to either drop the offensive or pick a target (figure 1–13). This turn is a called maneuver executed at MRT power with the major turn component in the vertical plane. Although the maneuver can be performed either high or low, it is normally performed in the vertical plane above the original flight path. When above 35,000 feet in altitude and subsonic, it is recommended that the reversals be in the low plane (low yo-yo). At low altitudes (10,000 feet and below), it is recommended that the maneuver be performed in the high plane (high yo-yo). A vertical reverse turn may be executed by an initial turn away from the teammate to gain horizontal separation or it may be entered directly from the combat spread position. The initial airspeed/Mach will determine whether or not the turn is initiated nose low or directly into the high reversal. The initial turn away maneuver appears as a split to the bogey. The leader will call, if necessary, as the aircraft approach their apex, which aircraft is to remain outside the turn of his teammate. The pilot on the outside of the turn has the responsibility of maintaining flight separation. At the apex of the turn, the aircraft should be abeam on reciprocal headings with both aircraft having a near optimum view of the six o'clock position of his teammate. Both aircraft execute a low yo-yo maintaining their direction of turn and adjusting the g and nose attitude to regain maneuvering potential while regaining the abeam position reciprocal to the original heading.

In-Place Turn

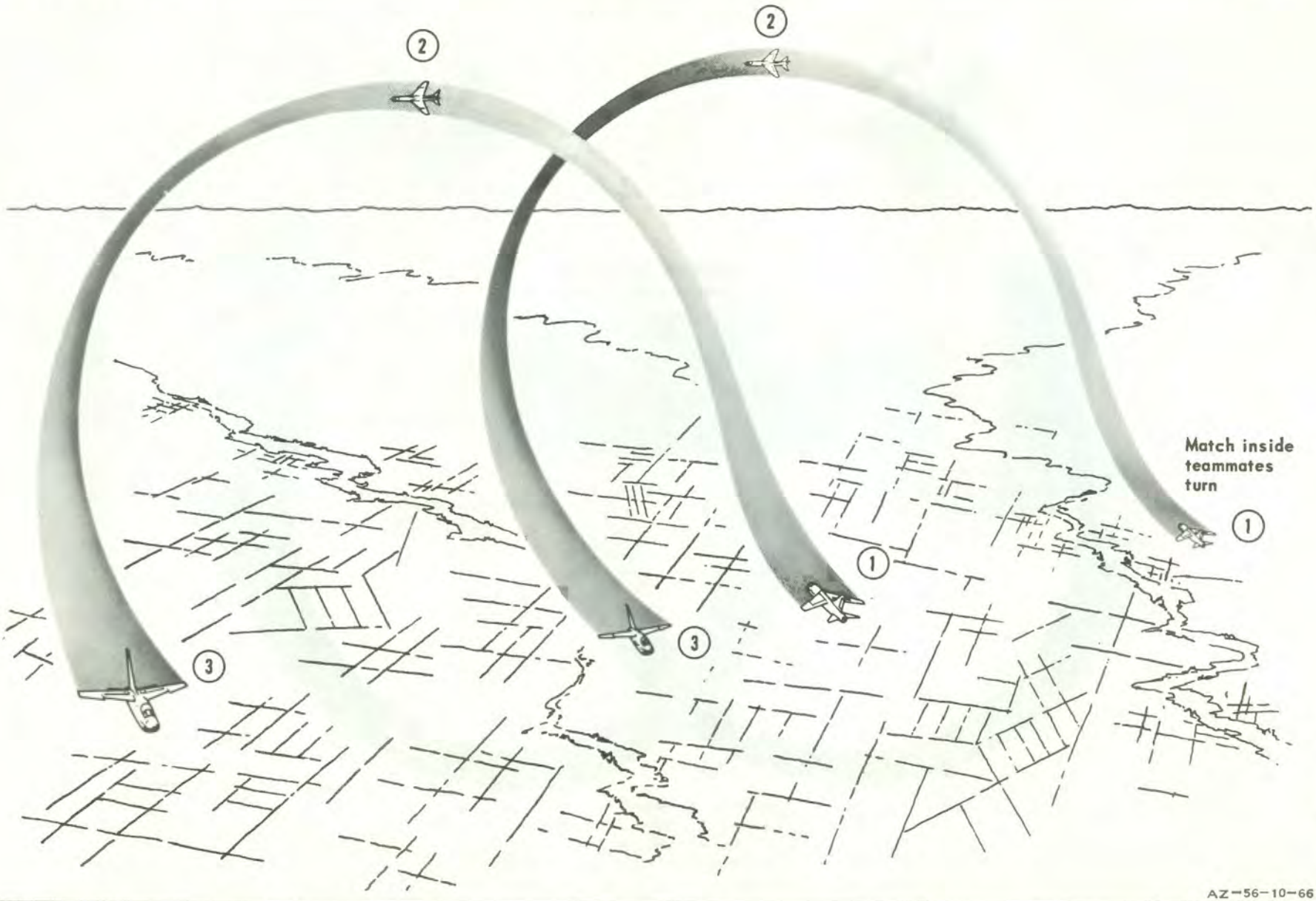


Figure 1-12

Vertical Reverse Turn

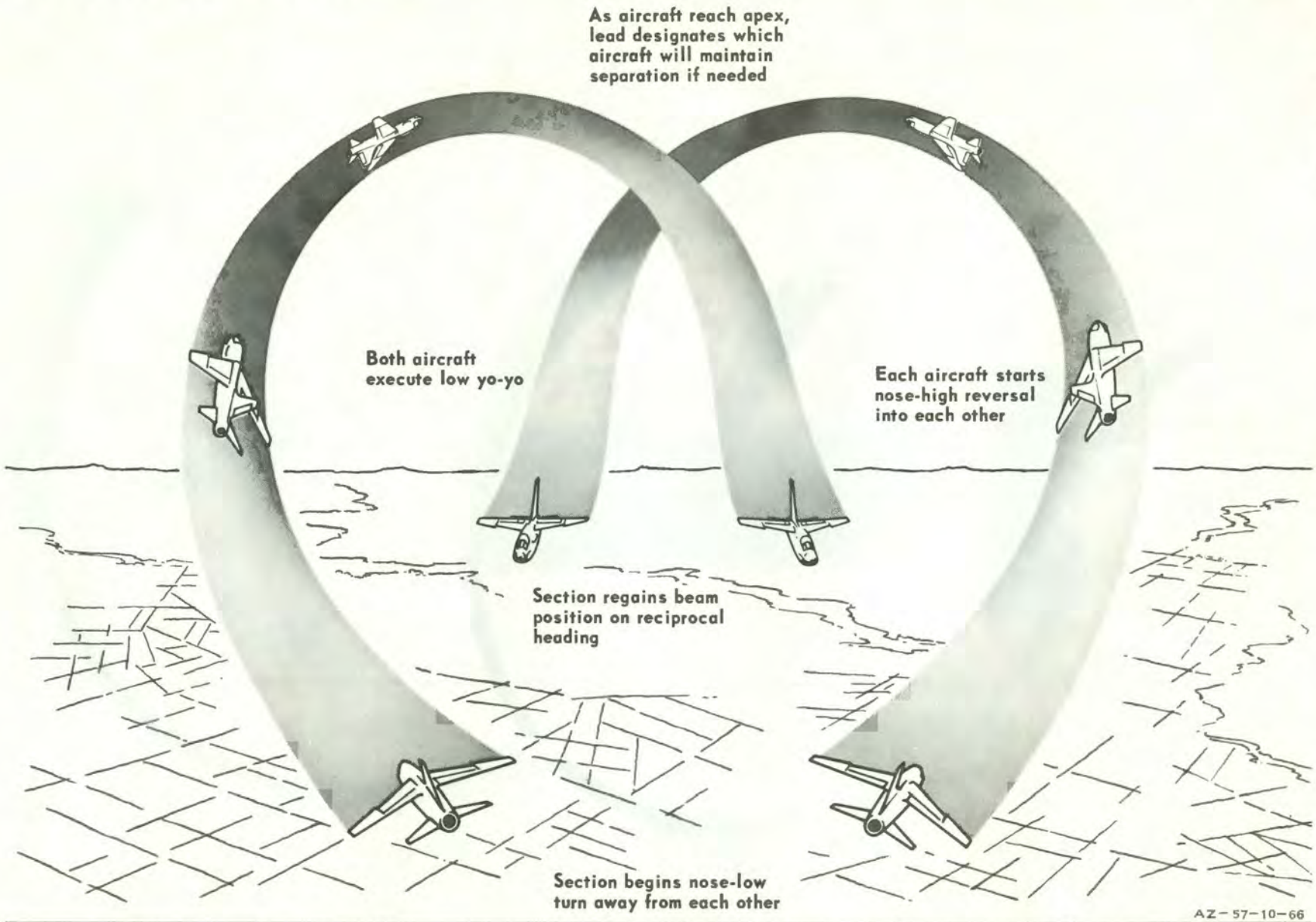


Figure 1–13

The tactical situation will often require modifications to this maneuver. For example, the enemy commits himself to a direction of turn after the flight has passed the apex and commences an attack. The teammate being attacked may desire to make a hard defensive spiral to generate angle off while maintaining airspeed/Mach. His teammate might reverse, execute a high yo-yo and barrel roll to the outside so as to drop into six o'clock on the enemy. In this example, the modification occurred after the apex and in effect terminated the vertical reverse.

BREAK TURN

The break turn is an in-place turn executed individually or in section and is made nose high, level, or nose low depending on the tactical situation. The "break" turn is an emergency procedure utilized when enemy aircraft have successfully penetrated the section's lookout and arrived at firing range before being detected. The maneuver is called and requires automatic selection of CRT power, maximum available g and maximum rate of turn to generate immediate angle-off. The teammate who calls the break must make an additional call to discontinue the break turn. This call may be "LEVEL" (level wings and proceed on present heading); "RESUME" (return to original heading via shortest direction at less than optimum rate of turn); or "REVERSE" (reverse direction but maintain maximum rate of turn).

OFFENSE

The maneuvers to be described in the following paragraphs (and in the paragraphs concerning defense) cover only those basic fundamentals of simple attack and defense. It is obvious that there are infinite variations possible for each initial turn; however, the basic use of airspace by the two teammates will fall into some variation of the described maneuvers. Low and high yo-yo maneuvers should be completely familiar to the loose deuce teammates, as well as aircraft characteristics and performance limits.

Non-Overshoot Situation

When the enemy is sighted, both pilots will immediately turn to position themselves for an attack (figure 1–14). The inside teammate will usually be the first to engage the enemy. He will track and fire only as long as he can maintain his lead angle without sacrificing maneuvering airspeed. The outside teammate will low yo-yo to the inside gaining maneuvering potential. This will permit him to either move into track position as his teammate high yo-yo's to the cover position to maintain nose-tail separation or high yo-yo to the cover position himself if his teammate has the situation well in hand. It is recommended that the tracking aircraft not remain in the firing position for more than five seconds due to the dissipation of his maneuvering potential. His teammate is in an opportune position to assume the firing role with a high level of maneuvering potential. In the event the enemy continues his turn at a higher rate than maintainable by the section, a continual switching of positions in the section is required until the enemy is destroyed.

Acute Target Angle Situation

The inside teammate in this situation must immediately commence a high yo-yo to the cover position. The teammate with the least angle off presses the attack to a tracking solution or until a high yo-yo is required to prevent overshoot. The teammate in the cover position executes a low yo-yo to keep the enemy turning as the tracking aircraft commences a high yo-yo to preclude a nose-high reversal by the enemy which would possibly put the section in trail and destroy mutual support. This type of teamwork and timing is essential, and will develop with practice. See figure 1–15.

Extremely Acute Target Angle Situation

When the section is so close in, or the angle-off is so high that it is obvious that neither teammate can track the enemy, the inside pilot should immediately high yo-yo to the cover position (see figure 1–16). The outside pilot should initially turn level to keep the enemy turning and then high yo-yo. The inside pilot will yo-yo first, go higher than the outside pilot, and low yo-yo back down on the enemy as soon as possible. The other pilot will then maintain the cover position until another overshoot condition presents itself. The enemy cannot afford to roll out or reverse. If he should be tempted to reverse hard, the team would merely utilize the same technique, going in the other direction. In a multiple overshoot, the maneuvering of each teammate should be called so that no possibility of confusion will exist. Keep your teammate informed.

Target Section Split Situation

When a split or separation of the enemy occurs, there is a definite tendency to follow the enemy one-on-one. A cardinal rule in the loose deuce team is to keep both teammates aft of the trailing enemy aircraft's beam. There is a need to sacrifice immediate section cover when the enemy has superior acceleration/speed characteristics combined with a short-range, head-on or high-aspect-angle missile and is obviously maneuvering to a firing position. It is not sensible to maneuver into the losing side of a sandwich situation when there is such a high degree of maneuvering freedom in the loose deuce team.

In order to keep team integrity at a maximum, attempt to keep all enemy aircraft turning in the same direction. The most effective method is to shadow the enemy, staying far enough away to avoid an overshoot

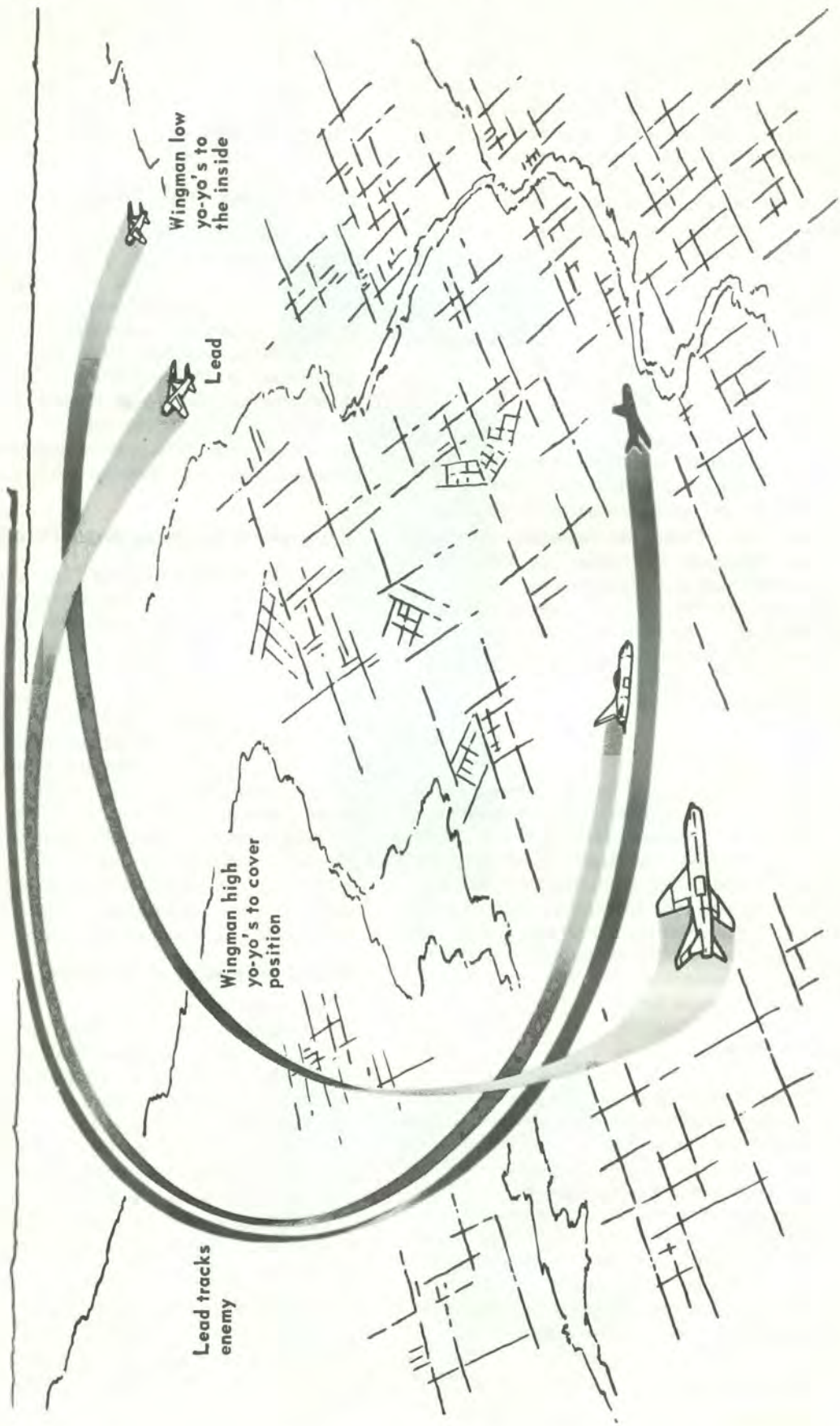

Wingman low
yo-yo's to
the inside
Lead
Wingman high
yo-yo's to cover
position
Lead tracks
enemy
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Figure 1-14

Acute Target Angle Situation

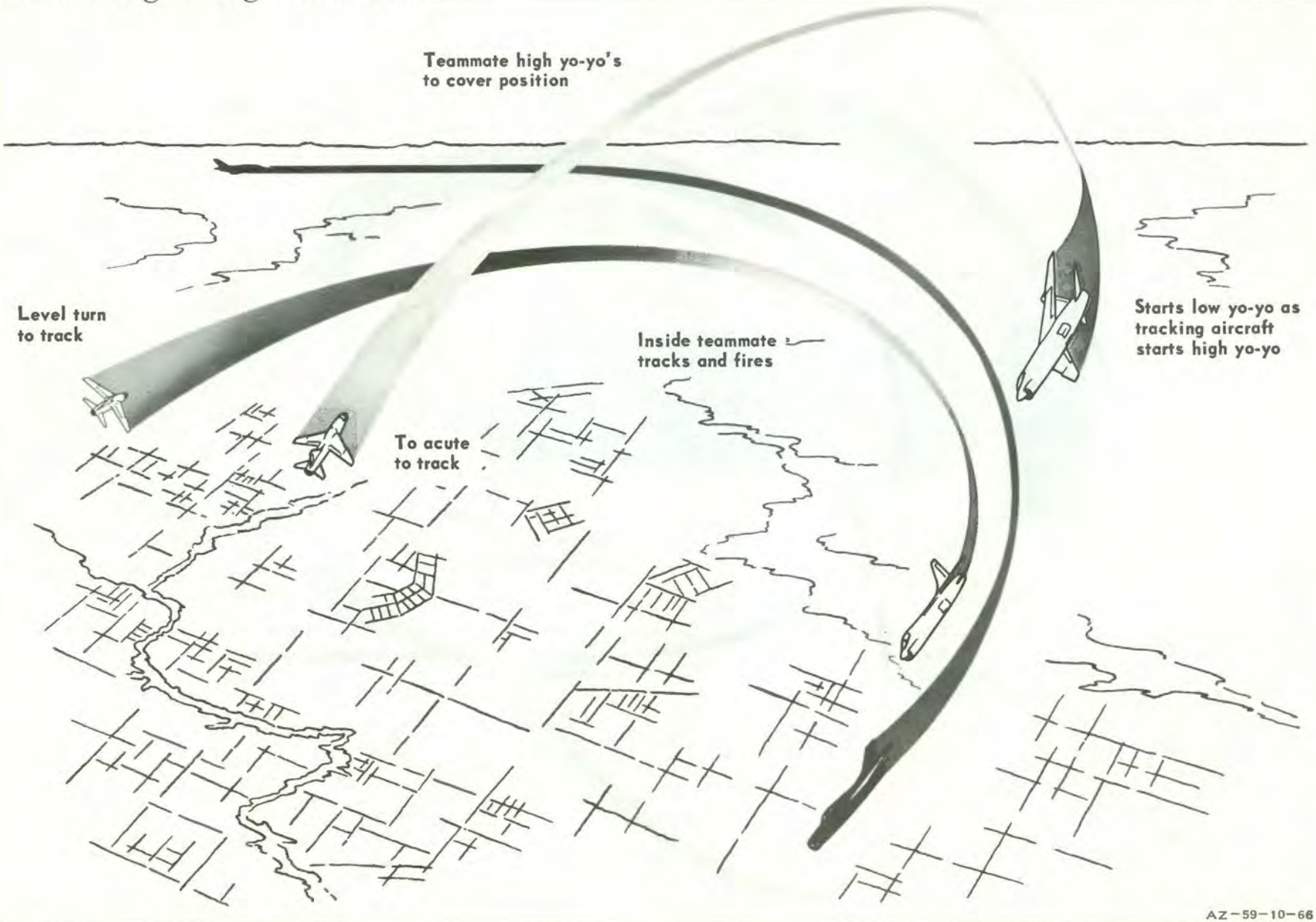


Figure 1–15

Extremely Acute Target Angle Situation

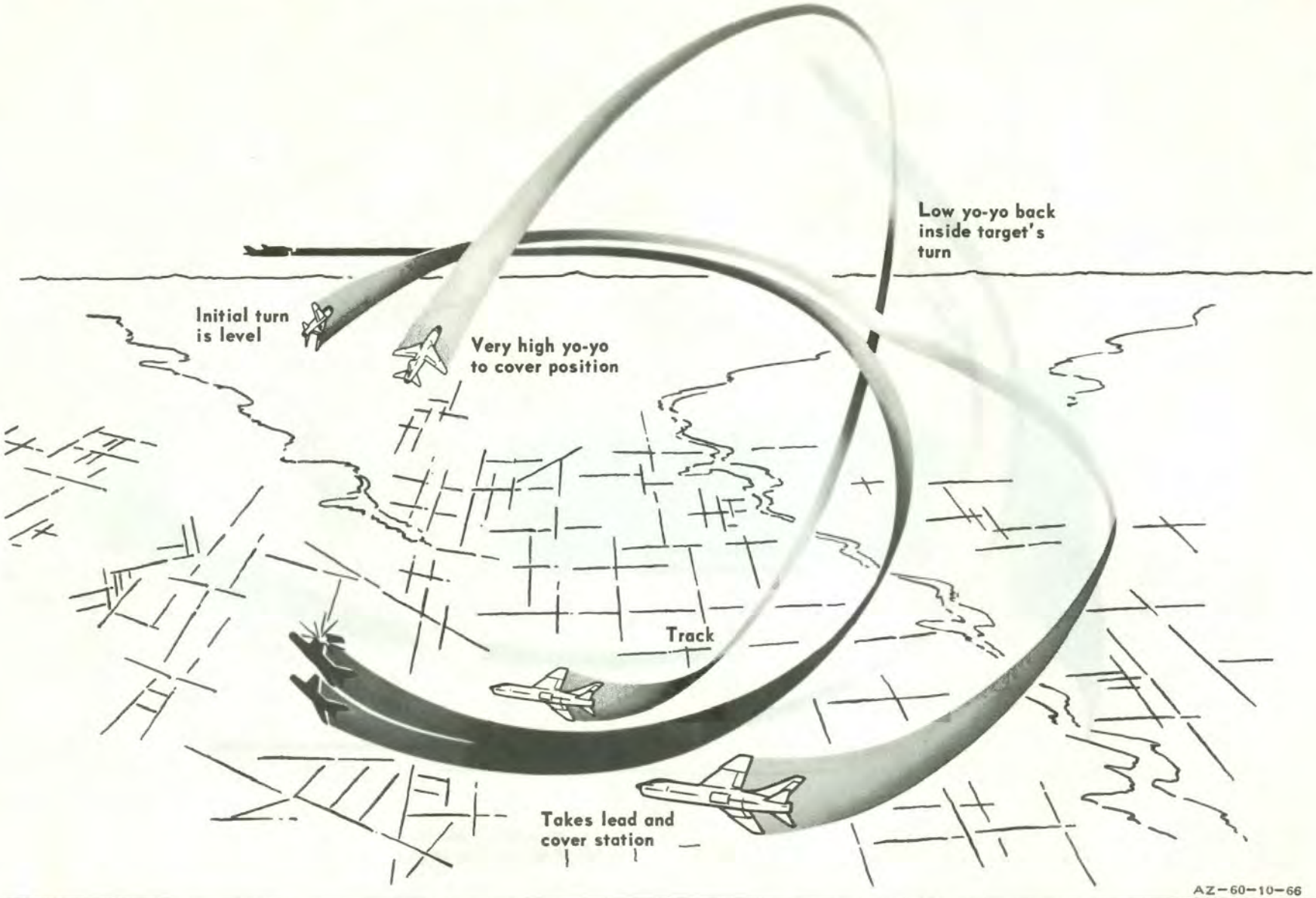


Figure 1–16

or close-in defensive maneuver, yet close enough to be obvious to the enemy and force him to turn. The objective in shadowing is to delay slightly and let the defensive maneuvers deteriorate. Then by playing the enemy turns, the team can effect total separation or drive them into a tail chase situation. If this is accomplished, the cover station is again manned and the firing teammate closes in on "Tail-End Charlie."

Many times an enemy fighter section will make a horizontal defensive split in the same direction to try and force a non-overshooting F-8 section to pick a single target and get sandwiched in or forced into a one-versus-one situation. In this case (figure 1–17), the wingman will turn inside of the enemy and track until they split. When they split, he will stay with the inside target, but ease high on the inside, making sure that the enemy can see his offensive position to prevent a reversal. The wingman in this case must never get ahead of the outside enemy aircraft's beam. Control is now definitely with the lead F-8 who initially yo-yoed to an outside high covering position and now drops down on the high enemy to keep him turning. The lead should not initially concentrate on tracking but instead should keep the enemy turning, staying far enough aft to avoid an overshoot or enemy reversal. As soon as the enemy separation is so great that the low enemy aircraft cannot reverse to cover his partner, the wingman high yo-yo's to the outside to a cover position. Simultaneously lead closes on the high enemy aircraft.

DEFENSE

The combat spread positions lend themselves as an aid in augmenting the defensive potential of the loose deuce team. Because of the wide separation, attacking aircraft can be seen astern before reaching firing range. The formation is relatively flat; therefore, neither teammate offers a better choice to the enemy and he will have very little initial information as to what maneuver to expect. The bogey call should be given quickly and accurately, containing two essential parts, direction of the team turn and enemy position, for example: "DEVIL, HARD STARBOARD, OVER, TWO BOGEYS, FIVE O'CLOCK, RIGHT HIGH, TWO MILES CLOSING." The teammate will immediately acknowledge if he sees the enemy. If he does not, he will state "NO JOY." The pilot who does see the enemy will call the enemy's position until his teammate sees them.

All combat maneuvering should be performed in a positive manner consistent with maintaining maximum maneuvering potential. The two teammates must separate and converge rapidly, always using different airspace and never tailing in behind one another. The vulnerable aircraft in each case must be completely free to execute any tactical maneuver desired to gain separation with the enemy. When both teammates are engaged, the prime advantage which each pilot has over his enemy attacker is his ability to work with his teammate with large separations in the vertical plane.

Enemy Does Not See Far Teammate Situation

In figure 1–18 the enemy attacker does not see the far teammate. Although this situation is rare, it does happen. The teammate who sees the enemy will immediately call the turn. The teammate under attack will execute a defensive turn to keep the enemy at a high angle-off. Control is with the outside teammate; and in this case, he must close on the target as fast as possible to put the enemy on the defensive. The primary aim of these maneuvers is to get both teammates behind the enemy. To accomplish this, the outside partner must position himself very obviously inside the enemy's turn, even if it is not a good tracking position. When the enemy maneuvers to defend himself, the trailing teammate calls the defensive teammate to ease g and high yo-yo to the cover position.

Enemy Has Low Angle Off Situation

In figure 1–19, the enemy has a low angle off on the outside teammate, and does not switch. This is the usual defensive situation since attacks are expected to be well executed. The team should see this attack develop far enough out so that the maneuvers can be executed before the enemy is within gun firing range. Again, the attacked teammate will maneuver with no restrictions, continuously turning hard into the enemy. Initially both teammates execute a hard turn or an in-place turn into the attack; however, the inside pilot holds his turn level as long as the enemy still has the option of switching targets. With wide separation, this switch option lasts only a few seconds. The inside teammate then pulls up abruptly in a high yo-yo. The outside pilot watches for a possible target switch. If there is no switch, he continues a hard turn under his teammate advising him of the situation. His teammate pulls up high enough to cause the flight to pass rapidly under him and discourages a switch of targets, but he must stay low enough to immediately low yo-yo down on the attacker.

This is the basic defensive maneuver for the loose deuce when defending against a close, fast enemy attacker or fluid section. It should be practiced repeatedly so that the time required for the inside pilot to high yo-yo and then low yo-yo to a tracking position on the enemy attacker is cut to a minimum.

If the enemy attacker overshoots, but not enough to warrant a reversal, the covering teammate must make his yo-yo higher and wider. The inside teammate should recognize this situation early, especially if the enemy has a great speed advantage and the attack is coming from almost abeam. With this situation the inside man can safely high yo-yo much earlier. He should commence the yo-yo early enough to be at the top with both the enemy and his teammate in sight, as

Target Section Split Situation

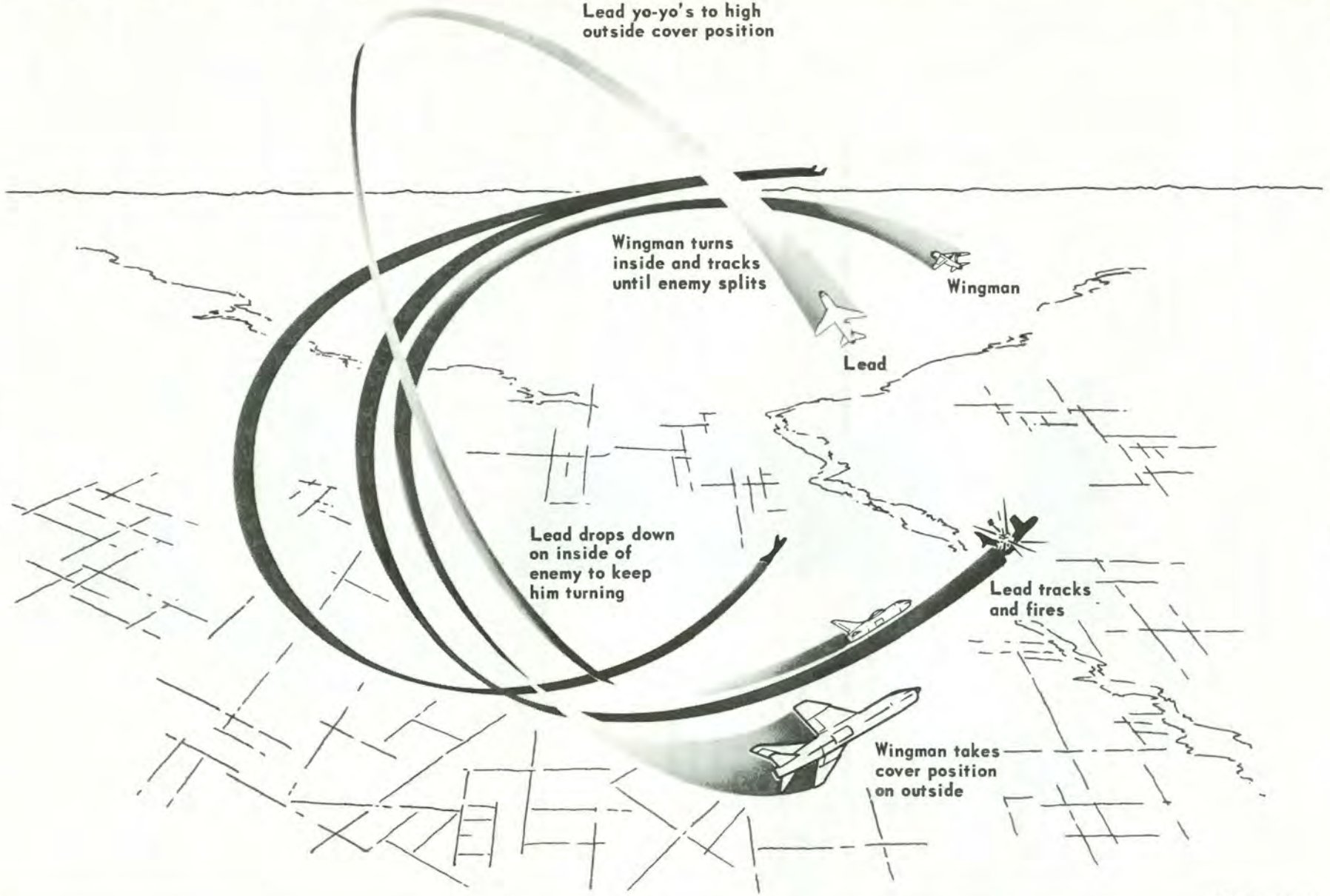


Figure 1–17

Enemy Does Not See Far Teammate Situation

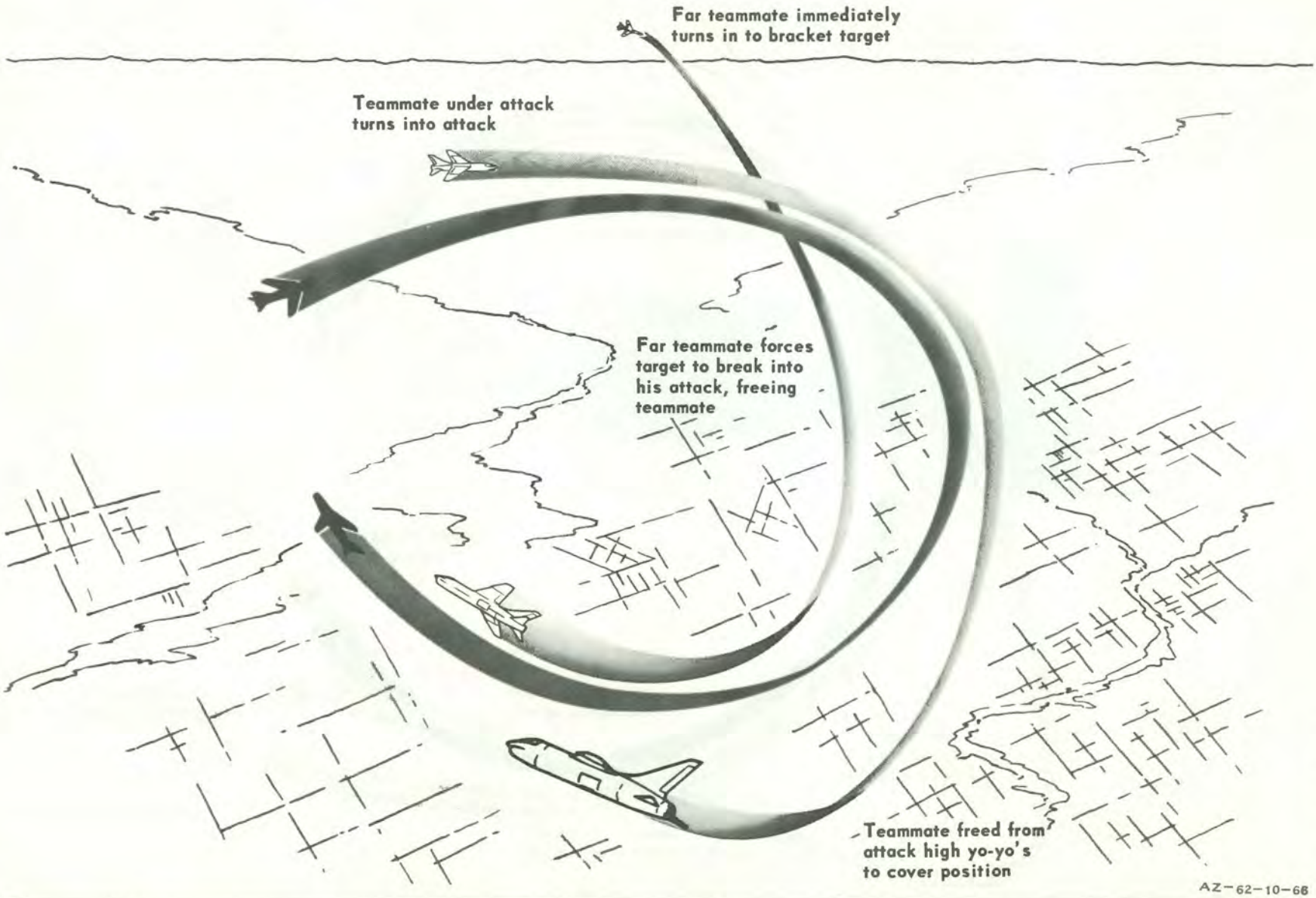


Figure 1–18

Enemy Has Low Target Angle Off on Outside Teammate and Does Not Switch Targets Situation

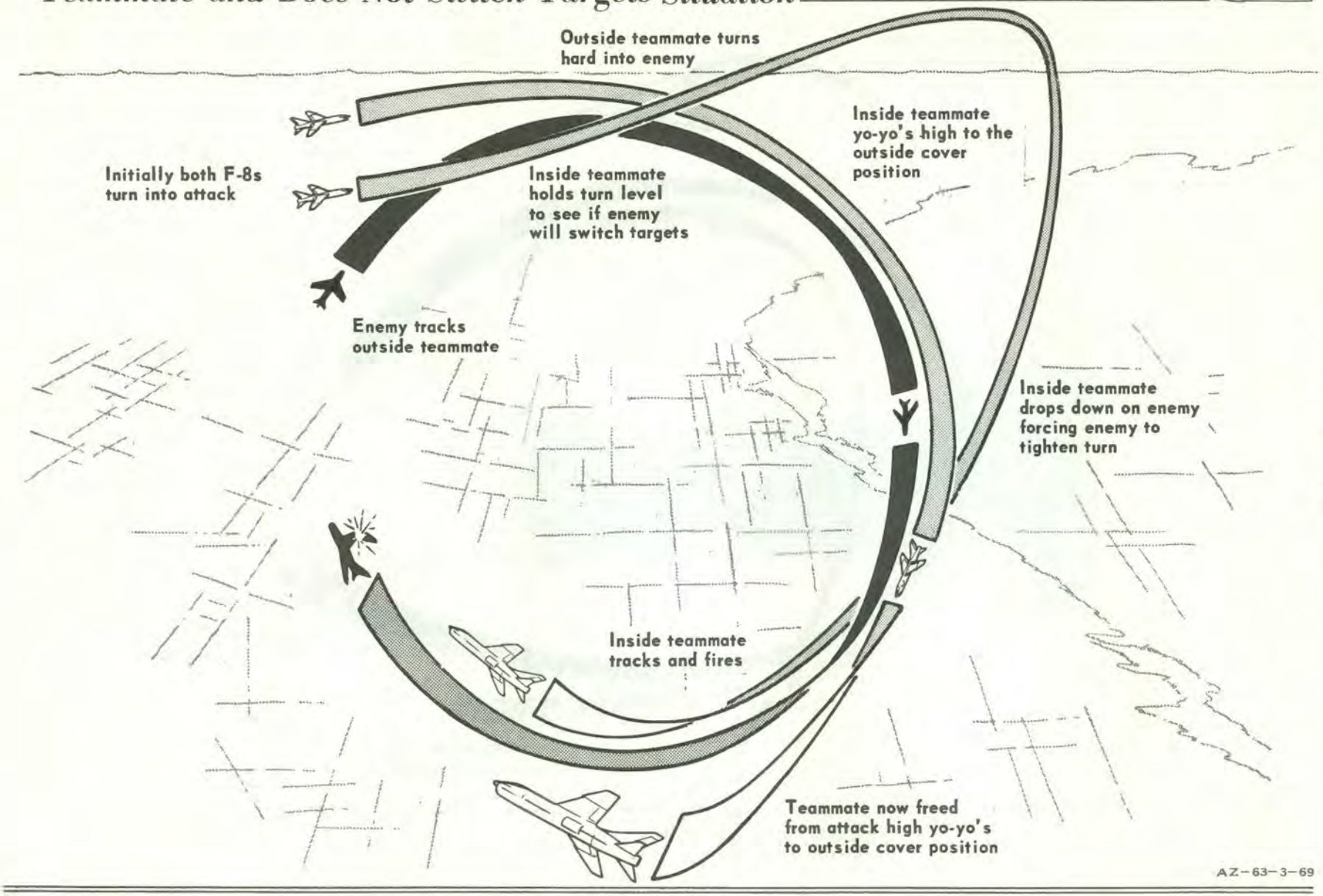


Figure 1–19

the overshoot develops. Anticipate the enemy's maneuver. The low teammate turns hard into the attack to force an overshoot, being careful not to nose down too steeply as this would allow the enemy to consider him sufficiently out of the fight to warrant a switch to the high teammate. When the enemy high yo-yo's aft of the low man, the high teammate must watch closely for a switch. If the enemy stays with the low teammate, the high man calls for him to tighten his turn and immediately drops down on the enemy's tail. If the enemy switches targets, the high man will turn hard down into the attack, calling for the low man to pull up to a cover position. See figure 1–20.

If the enemy does not switch targets again, the cover man can low yo-yo behind him. If the enemy continues to switch targets, the positions of the high and low teammates must continue to switch. It can be seen that under these conditions it is very difficult for the defensive team to switch to the offensive without endangering one teammate. The team must stay together in order to preserve its defensive potential should another enemy aircraft join the engagement.

ENGAGING DISSIMILAR AIRCRAFT

When engaging dissimilar aircraft, the opponents aircraft characteristics, both favorable and unfavorable, *must* be known as well as your own. The professional fighter pilot will carefully plan his strategy, tactics, and execution of maneuvers to exploit his favorable characteristics and the enemy's unfavorable characteristics. Your aggressiveness tempered by knowledge and the use of sound tactics will always give you the best possible chance for victory. When fighting a high thrust-to-weight ratio aircraft with low wing loading such as a MIG-21, your opponent's ability must be quickly and accurately determined.

ENGAGING A MIG-21

Utilize the combat spread formation when flying in a hostile area. Maintain a minimum of 450 KIAS to allow instantaneous application of maximum g. The MIG-21 will normally be positioned for a stern area attack under GCI control and will be extremely difficult to see due to its small size. Engage the MIG-21 in section to provide mutual support. Maintain a high energy level while engaged; do not attempt a slow-speed scissors. If necessary, dive away to regain airspeed for a reattack or to execute an escape maneuver. Force the MIG to fight below 16,000 feet.

Once engaged, use an oblique loop maneuver for reciprocal course changes below 16,000 feet, vice horizontal, high yo-yo, or low yo-yo type turns. The oblique loop allows the attacker to keep sight of the MIG during the maneuver while capitalizing on the F-8's superior performance in the vertical plane. Use lag pursuit maneuvering in close. Because of the MIG's superior turning performance, a close-in overshoot is highly probable if lead pursuit is utilized to close for a minimum range missile or guns shot. Avoid dissipating energy by usng hit-and-run attacks and yo-yoing high. Do not strive for an immediate close-in shot.

As the MIG initiates a defensive hard or break turn, maneuver to a point 3,000 to 5,000 feet astern and outside the MIG's radius of turn. If a close-in overshoot is imminent during offensive maneuvering, instead of performing a high yo-yo to counter the overshoot, execute a high g roll away to position for a lag pursuit attack. This will prevent a close-in overshoot, thus eliminating the possibility of being caught in a slow-speed scissors. It will also reduce energy bleed-off, and place you in his blind cone. Maneuver into the MIG's blind cone during all offensive maneuvering to capitalize on the MIG's visibility restrictions. Continue maneuvering in the stern area until it appears that the MIG has lost visual contact.

When a section maneuvers offensively to engage a MIG-21, it should close until he initiates a defensive maneuver. When the MIG maneuvers, the wingman must separate vertically. One airplane must keep him engaged while the other employs loose-deuce maneuvering in an attempt to close for the kill.

Head-on Attack

If a MIG-21 is sighted head-on, immediately push over and attempt to descend into its forward quarter blind area. Turn away to gain approximately 1-mile lateral separation. If the MIG does not turn, maintain the lateral separation until approaching abeam and then initiate a hard turn toward his aft hemisphere, positioning for a missile/guns attack. Maintain a rigid lookout during the turn to prevent turning in front of a trailing wingman. As soon as your weapons are fired, execute a hard turn to clear your 6 o'clock.

If the MIG-21 turns towards you prior to passing, indicating that you have been seen, immediately turn hard into him to reduce all lateral separation. A MIG-21 can convert any lateral separation into a decreasing

Enemy Switches to Cover Man

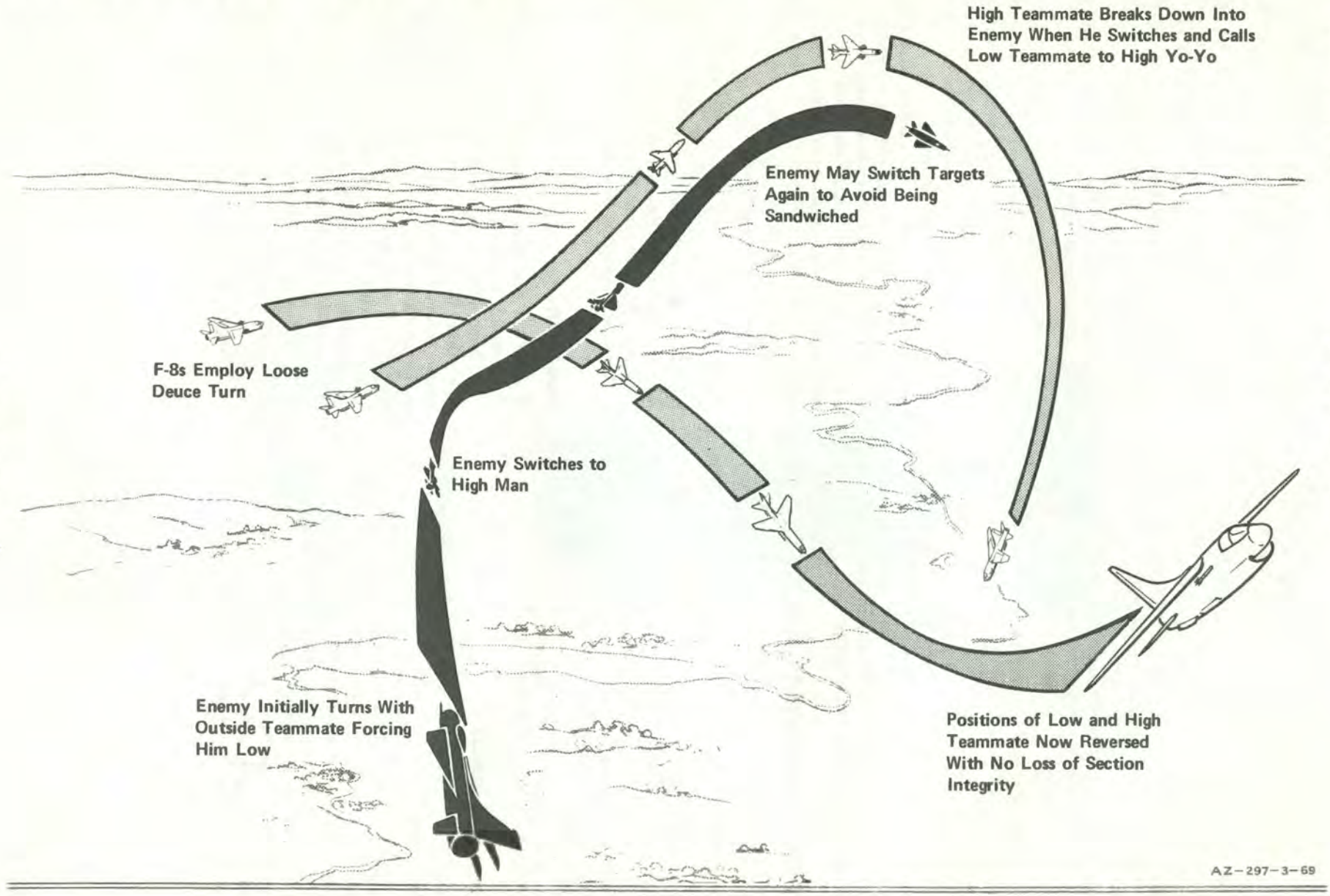


Figure 1-20

track crossing angle (TCA). Jinking may be required to prevent any forward quarter cannon tracking by the MIG prior to passing. If range is such that a head-on engagement cannot be made, turn to position him at a high TCA. Maintain this high TCA while accelerating for separation. Be prepared to break into an ATOLL missile or to negate a gun firing pass and force an overshoot. As the MIG-21 passes close abeam, drop a wing as necessary to keep him in sight, and execute an oblique loop back toward him. If he counters aggressively the F-8 may not be able to attain an offensive position.

If the first reversal results in another head-on pass or loss of position advantage, do not immediately reverse back into him with a reduced energy level. If the F-8 slows down while attempting to turn with the MIG-21, it will only be a matter of a few turns before the MIG will be on the inside of the turn and tracking. Turn only enough to keep him in sight after passing, and unload to gain energy (minimum of 450 KIAS) prior to reversing back toward him. This delay in reversing allows the F-8 to regain a sufficient energy level to perform a maximum performance turn reversal and sufficient separation to complete the 180° turn prior to passing him again. The time delay before reversing the turn depends upon the F-8's speed when passing, but should not exceed approximately 5 seconds, or visual contact with the MIG may be lost. During these head-on passes the MIG should be rapidly dissipating energy on his reversals. Continue engagement using these tactics until an offensive position is attained or disengagement is necessary.

Stern Attack

When the F-8 is attacking from the MIG-21's stern area, attempt to take advantage of the MIG's poor rearward visibility by approaching the missile envelope from a low 6 o'clock position. If the missile launch is unsuccessful and he has not initiated a break turn, close for a guns attack but avoid a close-in overshoot. If the MIG-21 turns into the F-8 while closing for a guns attack, do not pull lead and attempt to close the MIG to minimum range. Do not become overanxious to complete the kill. The MIG-21's high rate of deceleration with g applied and its superior turning capability may place the F-8 in an uncontrollable overshoot situation. Use lag pursuit maneuvering and barrel roll attack to stay in his blind cone as he reverses. If these maneuvers are performed properly, the F-8 can maintain an offensive position until the MIG is destroyed.

MIG Executes a Stern Attack

When the MIG-21 is attacking from the stern area, attempt to turn and meet head-on by executing a hard, CRT turn into him. If successful, perform the tactics described above for the head-on situation. If unable to meet head-on, continue turning into him with your nose slightly down, maintaining a minimum of 450 KIAS. Keep him at a high TCA. Be prepared to break into the MIG to force an overshoot or to counter an ATOLL missile launch. If he closes to gun tracking range (within 3,000 feet per 30° angle off), escape becomes difficult. Execute a nose-low break into him, accelerating to above 595 knots at maximum g for that speed. If being fired upon, vary the g load and yaw on the airplane to negate tracking solutions. If the MIG reverses its turn nose-low away from the F-8, indicating it is disengaging, immediately reverse and attempt to reacquire him before he is beyond maximum missile range. If the MIG yo-yo's high, indicating he is countering an overshoot and is positioning for a reattack, do not reverse into him; reduce g and accelerate for separation, keeping him in sight. If the MIG follows you down into the lower altitude region, with all other tactical considerations in mind you must decide whether or not to re-engage.

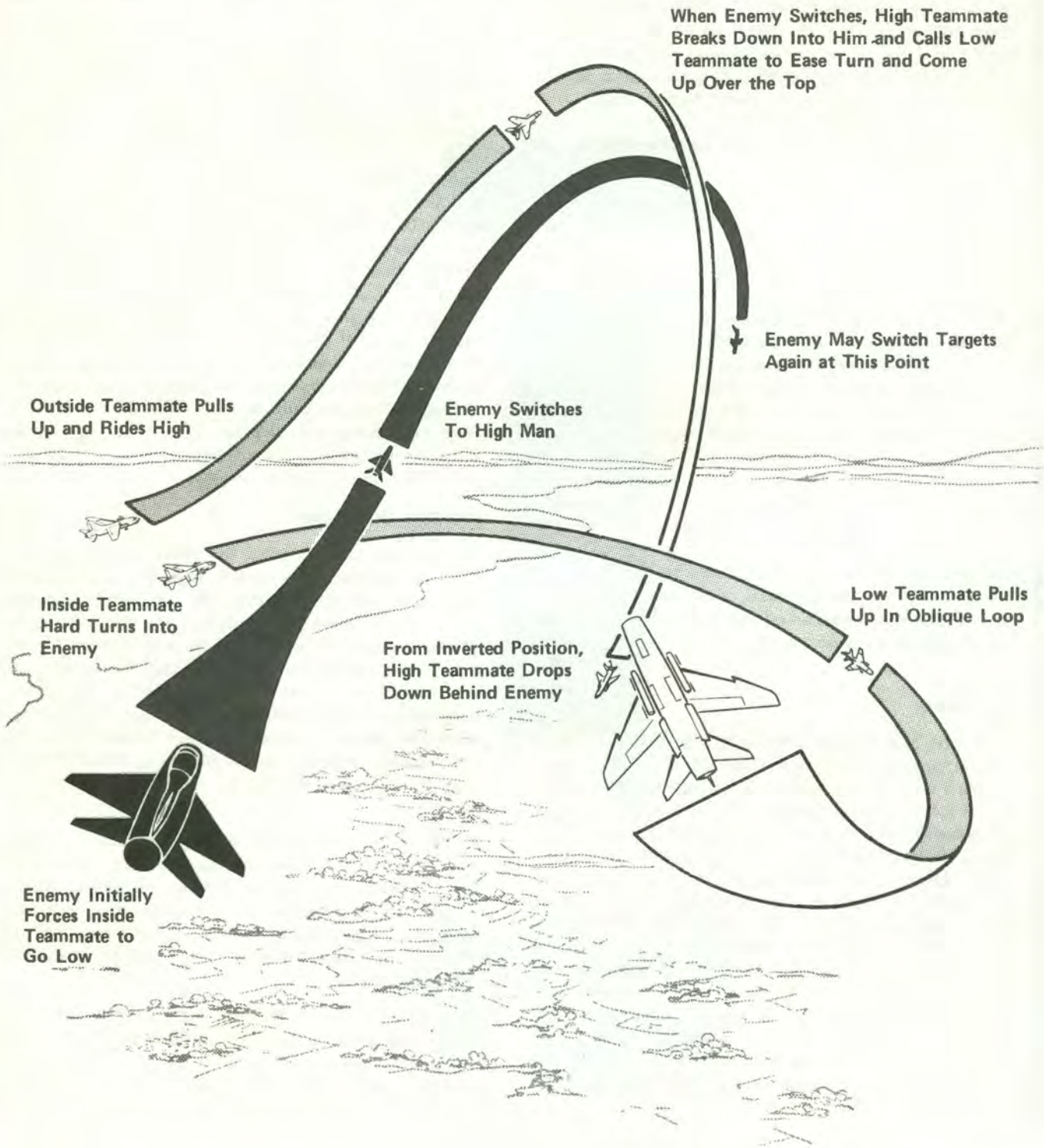
SECTION DOCTRINE

The section tactical team has been proven to be an absolute necessity in a hostile area. The team must be proficient and well trained in the tactics discussed above. The relative positioning of the two F-8's during offensive maneuvering should be as described for combat spread patrolling, tactical wing formations, and loose deuce maneuvering. Attacking in the tactical wing formation, the wingman must separate vertically when the MIG-21 begins defensive maneuvering. The F-8 actually pressing the attack on a MIG-21 should keep him engaged while the wingman maneuvers for the kill.

A MIG-21 is most difficult to acquire visually in excess of 2 NM. For this reason, a rigid section lookout doctrine is mandatory if the section expects to operate successfully in a hostile area. Section loose deuce maneuvering, separated in the vertical plane, is the most effective formation for converting a defensive situation to the offensive.

This is particularly true at low altitude when the enemy has superior turning performance. In this case the inside teammate goes low and the outside teammate goes high. This is essentially a loose deuce defensive split. See figure 1–21. If the enemy chooses to

Enemy Has Low Angle Off and F-8's Perform Loose Deuce Defensive Split



AZ-298-3-69

Figure 1-21

follow the low teammate, he will be sandwiched by the high teammate. If the enemy switches to the high teammate, he must break down into the enemy and call the low teammate to ease his turn and pull up over the top. The low teammate decreases his bank angle to approximately 30° and pulls up in what is essentially an oblique loop. Communications are paramount. The teammate who has called the maneuver must keep his looping teammate in sight as long as possible, correct his bank angle if it is incorrect, and tell him where to look as he comes over the top. If the enemy does not switch targets again, he will be sandwiched. If the enemy does switch, the teammate who has just completed the oblique loop will engage him head-on and call for his teammate to pull up over the top. It is difficult to properly perform this maneuver without a good deal of experience in loose deuce maneuvering. Large vertical separation is encountered and for much of the time one teammate will not know the position of his teammate or the enemy. This maneuver would be impossible without continuous radio communication and highly undesirable if other enemy aircraft were in the area since team defensive posture is so greatly compromised.

If the situation should occur where the enemy attacker is shadowing and refuses to engage, a vertical reverse turn will force the enemy to drop the offensive or pick a target. The team should keep the enemy in sight and not spread more than two miles apart. The enemy must continue ahead or follow one of the teammates. The enemy should be watched closely; and if he picks a teammate, the other teammate calls for him to tighten his turn, relaxing his own turn and reversing to roll out high and a little aft (to a cover position). From this point the procedure is the same as for other situations where one member is vulnerable and the other has an advantage over the enemy. A modification of this maneuver, that is, a split-S into one another without hesitating to spread and build up potential, can be used effectively against an enemy known to have missile capability.

ENERGY MANEUVERABILITY

Prior to participating in fighter versus fighter combat, the fighter pilot must know how to maneuver his aircraft to the greatest advantage. He must also know the capabilities and limitations of his opponent's aircraft. With an understanding of energy maneuverability, the fighter pilot can extract this vital information from simple diagrams. The information gained from these diagrams can be used to add precision to tactics already developed and, more importantly, to develop comparisons for use as a basis for designing tactics against potential opposing fighters.

Effective tactics reflect the best way to gain a favorable position. The maneuvering necessary to gain this favorable position depends upon the interaction of armament, turn, altitude, airspeed, and acceleration. The type of armament will define the firing envelope, hence the relative position to be sought in order to effectively employ this armament. How to maneuver into the firing envelope is the prime problem in air-to-air combat.

Assuming that a thorough knowledge is possessed of the F-8 armament envelope and that intelligence has provided enemy weapon system capability, this section will discuss the four factors of maneuverability–turn, altitude, airspeed, and acceleration.

To gain a maneuvering advantage, energy must be managed more wisely by a given pilot than it is by his opponent. It follows, then, that tactical maneuverability is a function of energy–the amount of energy possessed and how well that energy is managed in seeking a favorable position. For best maneuverability, this means that a fighter pilot should attempt to enter an engagement at a relatively high energy level. However, this may be impractical since fuel management

problems can prevent the F-8 pilot from cruising near maximum energy levels; therefore, in an effort to improve maneuverability, we are presented the dual problem of:

a. Managing energy while actively maneuvering against an opponent.

b. Transferring from an energy level associated with cruise to one more closely akin to maneuverability.

The following explanations of Energy Maneuverability diagrams will give the fighter pilot an insight as to how to manage the energy he possesses and how to best transfer to a higher energy level.

V-n Diagram (G-Limit vs Airspeed)

The V-n diagram (figure 1–22) is a plot of limit load factor (g-limit) versus airspeed. The right, upper, and lower boundaries of the V-n diagram are determined by the structural limits of the airframe, while the left boundary is determined aerodynamically by the stalling speeds of the aircraft. From this diagram, one can determine the maximum g which can be pulled at any given airspeed before onset of stall. To use the diagram, select a calibrated airspeed (eg 300 KCAS) and proceed vertically to find the positive and negative g loads which can be achieved without stalling the wings. The diagram can also be entered with a given g load to determine minimum CAS prior to stalling. It should be noted here that this diagram does not indicate the g load which can be sustained without airspeed bleed off, but merely the instantaneous, no-stall g which can be attained at any given airspeed. The g load which can be maintained without airspeed bleedoff is shown in figure 1–23. Figure 1–24 is a plot of instantaneous g available at various altitudes, cruise droop in and cruise droop out.

P_s -V Diagram (Specific Excess Power vs Airspeed)

This diagram is a plot of P_s (excess power) versus airspeed. Airspeed is presented in terms of Mach number. P_s is that power above the amount required to maintain level, unaccelerated flight and is shown in feet per second. This excess power can be used to increase airspeed, altitude, or g loading. This diagram is particularly useful for determination of g loads which can be maintained without loss of airspeed (diagram values are valid only at the specific altitude). To use this diagram (figure 1–25) select a Mach number and proceed vertically to a g line. Then move horizontally to the left-hand margin of the diagram and note the specific excess power. If this power is positive, there is still power available for acceleration, climb, or increased turn (g). If this power is negative, a loss of airspeed will result if g is maintained at a constant value. The units of P_s, feet per second, are a direct measure of the rate-of-climb available from positive P_s, or the rates-of-descent necessary to maintain g and airspeed if the P_s value is negative.

Examine figure 1–25 (Sheet 2) which is based on 15,000 feet. Note that at Mach 0.51, 15,000 feet, the F-8E, at maximum thrust can just maintain a level, 3g turn (point 1); while at 0.8 in a 3g turn, the aircraft has a positive P_s value of 250 ft/sec (point 2). With this excess power the pilot can: initiate a climb at 250 ft/sec while maintaining a 3g turn; accelerate to 0.95 while maintaining a 3g turn (point 3) and climbing at 250 ft/sec; or maintain 0.8 and increase turn g to 4.8 (point 4) without losing altitude. Now follow the 1.0 Mach line to its intersection with the 5g curve (point 5). Note that at this point, the aircraft has a negative P_s of approximately 75 ft/sec. With this negative excess thrust, the aircraft must: descend at the rate of 75 ft/sec if the 5g turn is to be maintained at Mach 1.0 or, relax g to a value of 4.0 (interpolation between 3g and 5g contour) if a constant airspeed and attitude is to be maintained (point 6).

Note

P_s-V diagrams are not commonly referred to in current energy maneuverability manuals. However, the P_s-V diagram has been illustrated and explained to facilitate an understanding of the information that follows.

H-V Diagram (Altitude vs Airspeed)

This diagram depicts lines of constant E_s (specific energy) and lines of constant P_s on a plot of altitude versus airspeed. As in the P_s-V diagram, airspeed is presented in terms of Mach number.

Note

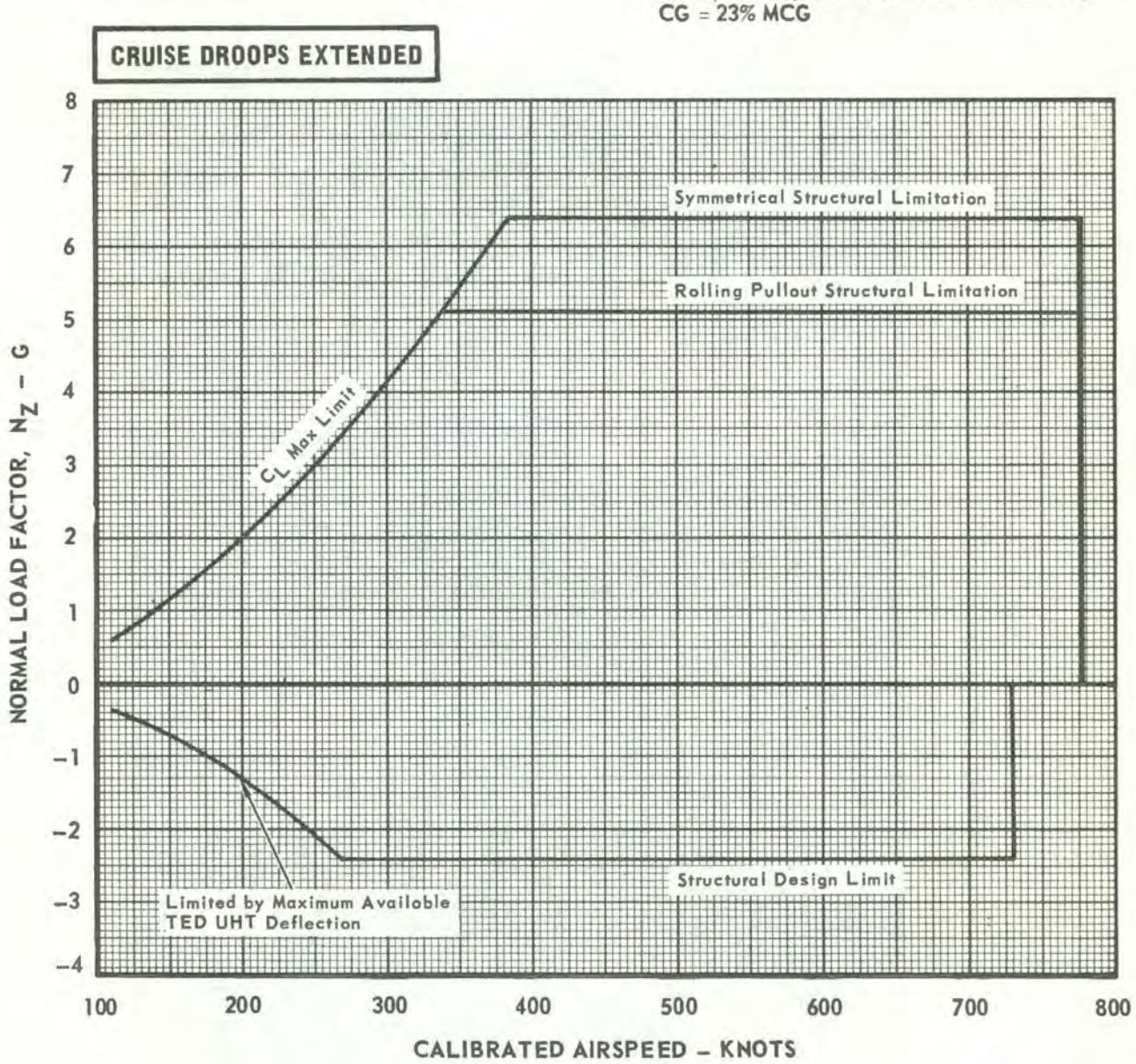
In this discussion, only mechanical energy, as applied to air combat maneuvering, is considered. Mechanical energy consists of two forms — energy due to position (height) and energy due to motion. Positional energy is normally termed "potential energy" and is a measure of height, or altitude, above the surface of the earth. Energy due to motion is commonly called "kinetic energy," and is proportional to the square of the true airspeed. Mechanical energy is the sum of kinetic energy and potential energy.

The total mechanical energy an aircraft possesses divided by the weight of that aircraft is termed "specific energy." It is given the symbol E_s, and the

F–8E Vn Diagram

MAXIMUM NORMAL LOAD FACTOR

No External Stores
20,000 Ft Standard Day
Gross Wt = 23,860 Lb (50% Fuel on Board)
CG = 23% MCG



NOTES

1. Based on C_L max.
2. No thrust effects
3. Load factor based on force normal to A/P flight path.

AZ–313–6–68

Figure 1–22

Maximum Sustained G

F-8E

J57-P-20A Engine – Maximum Thrust
No External Stores – Standard Day
Gr. Wt. = 23,859 Lb (50% Fuel on Board)

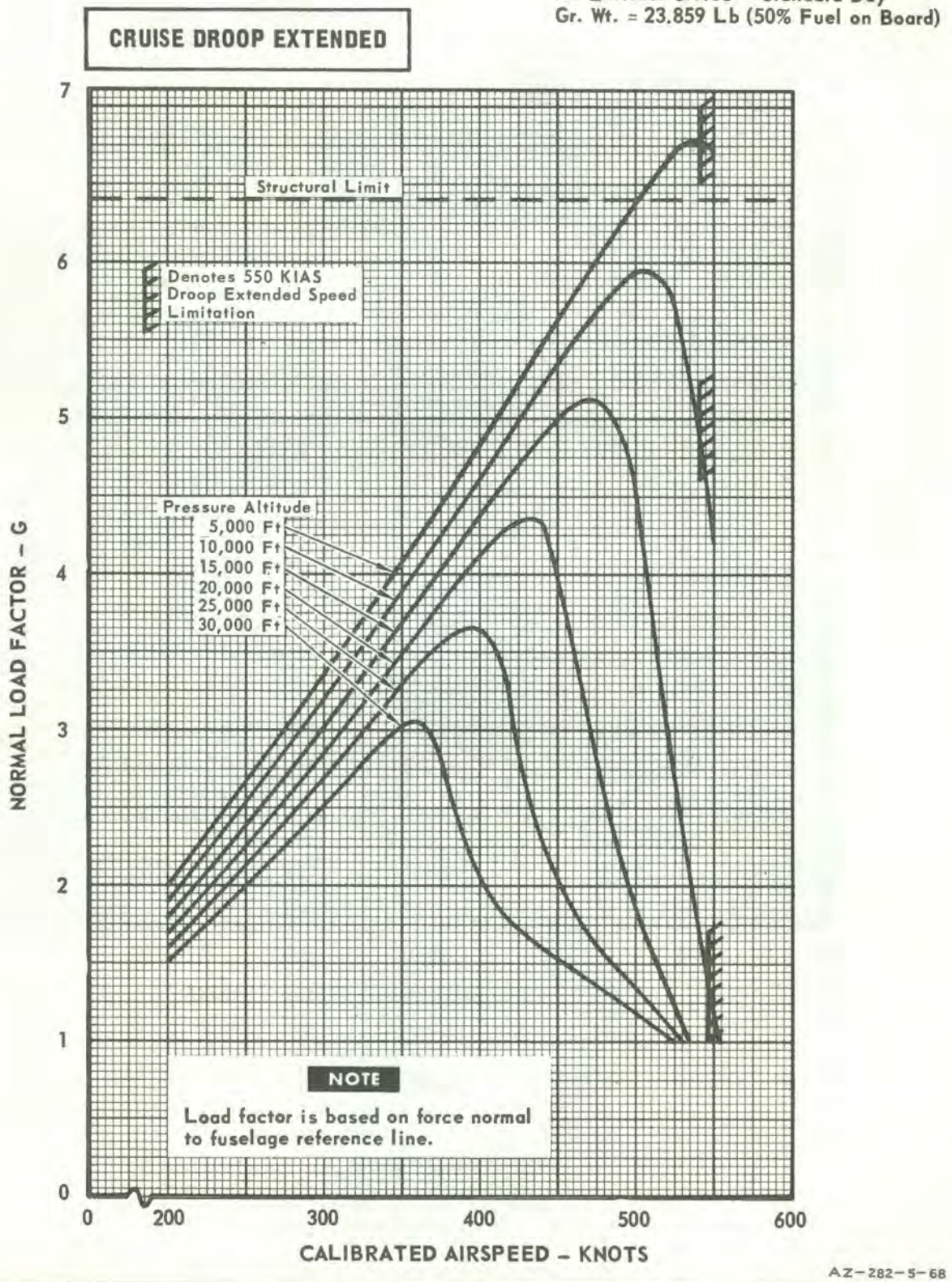
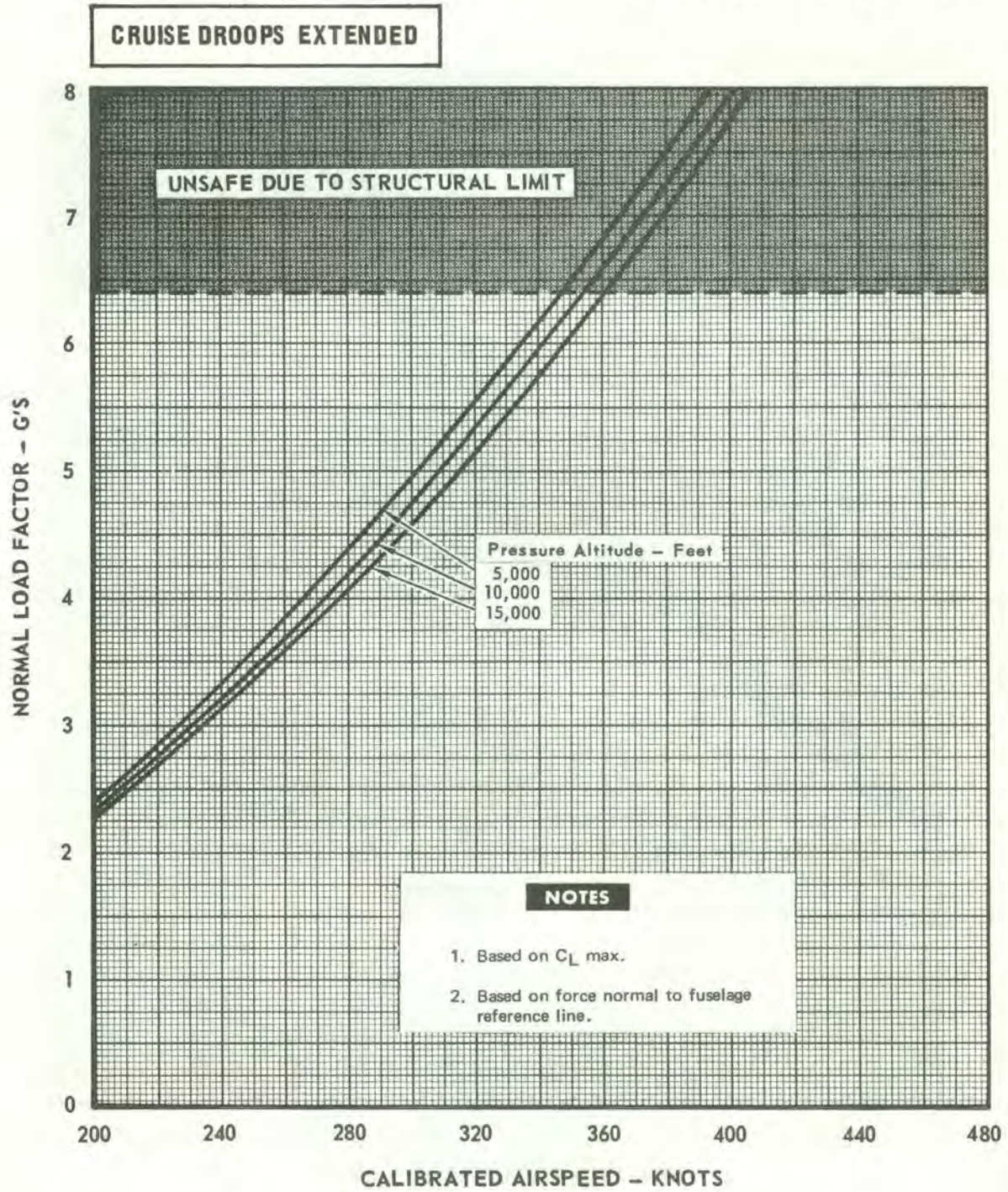


Figure 1–23

Maximum Instantaneous G Available

G AVAILABLE/STALL AREA ONLY

No External Stores
Standard Day
Gr. Wt. = 23,859 Lb (50% Fuel on Board)



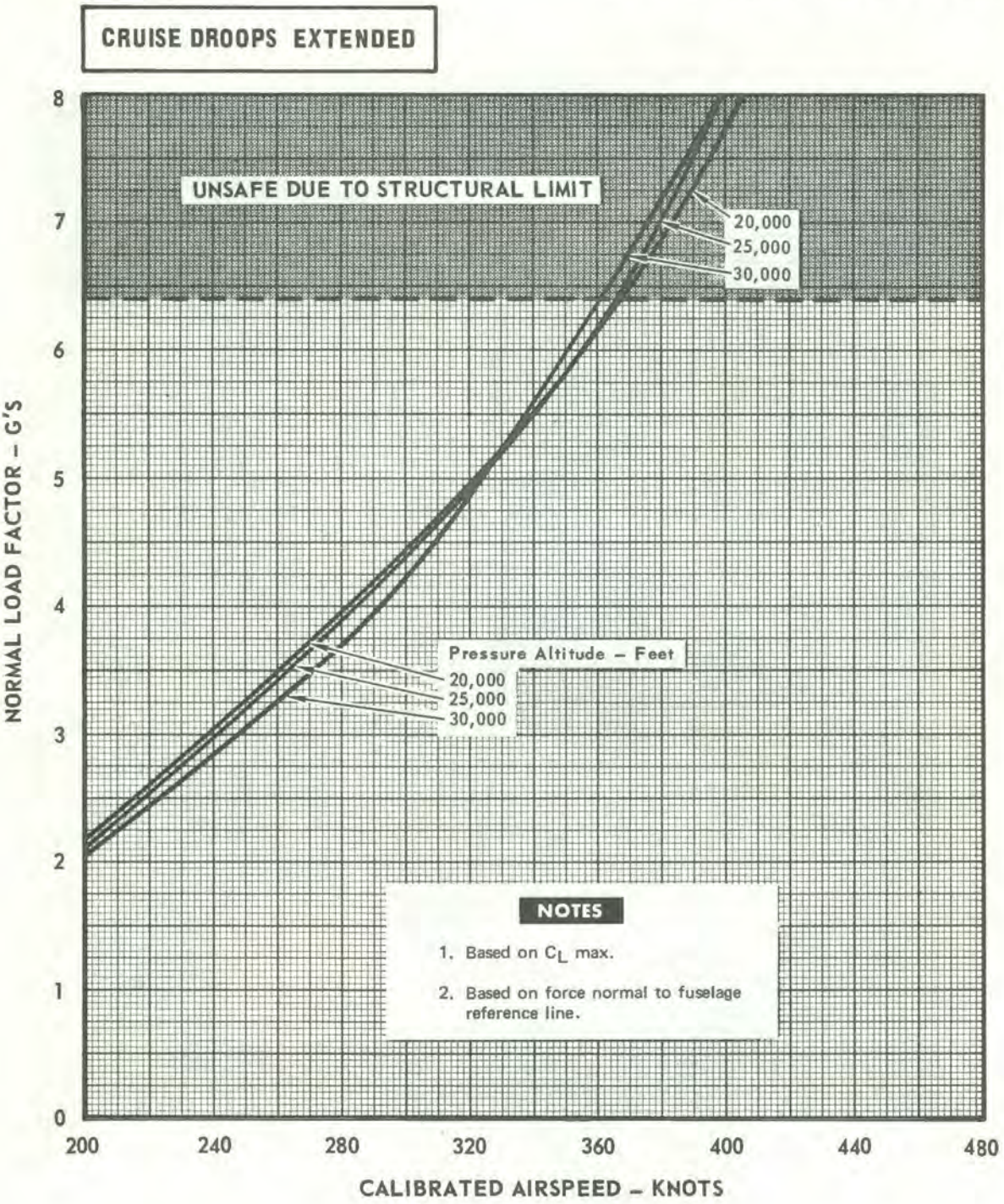
AZ-281(1)-S-68

Figure 1–24 (Sheet 1)

Maximum Instantaneous G Available

G AVAILABLE/STALL AREA ONLY

No External Stores
Standard Day
Gr. Wt. = 23,859 Lb (50% Fuel on Board)



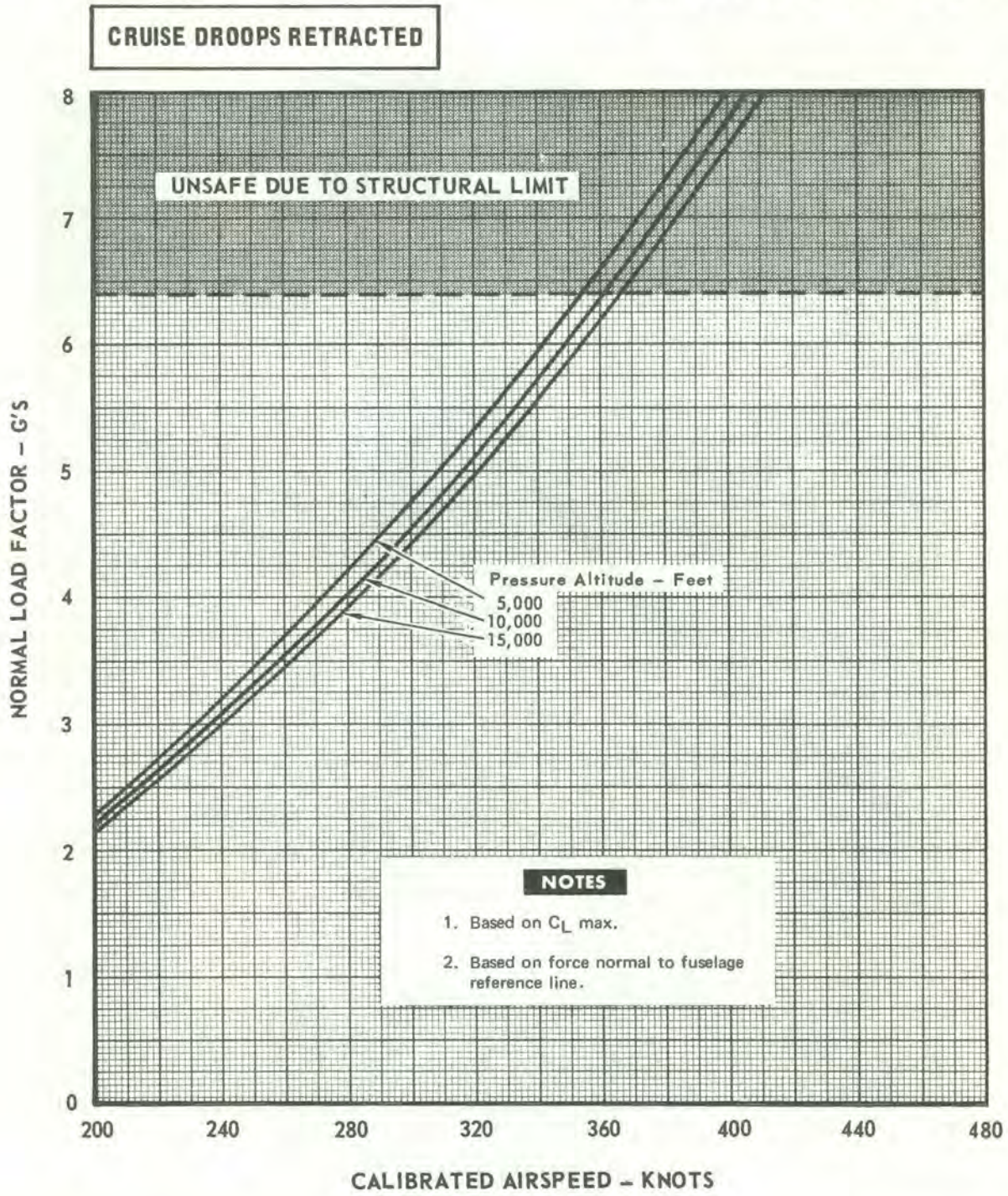
AZ-281(2)-5-68

Figure 1-24 (Sheet 2)

Maximum Instantaneous G Available

G AVAILABLE/STALL AREA ONLY

No External Stores
Standard Day
Gr. Wt. = 23,859 Lb (50% Fuel on Board)



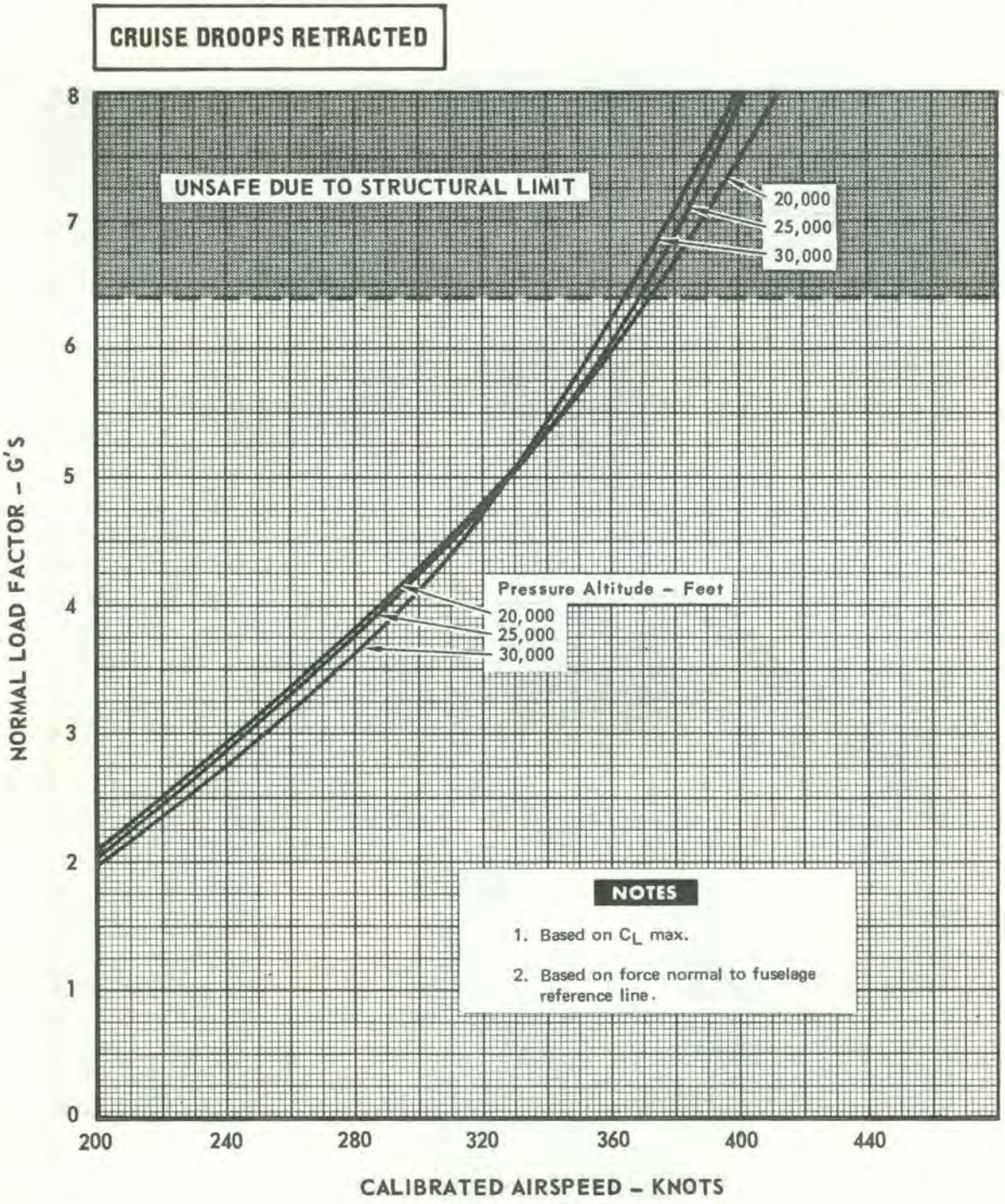
AZ-281(3)-5-68

Figure 1-24 (Sheet 3)

Maximum Instantaneous G Available

G AVAILABLE/STALL AREA ONLY

No External Stores
Standard Day
Gr. Wt. = 23,859 Lb (50% Fuel on Board)

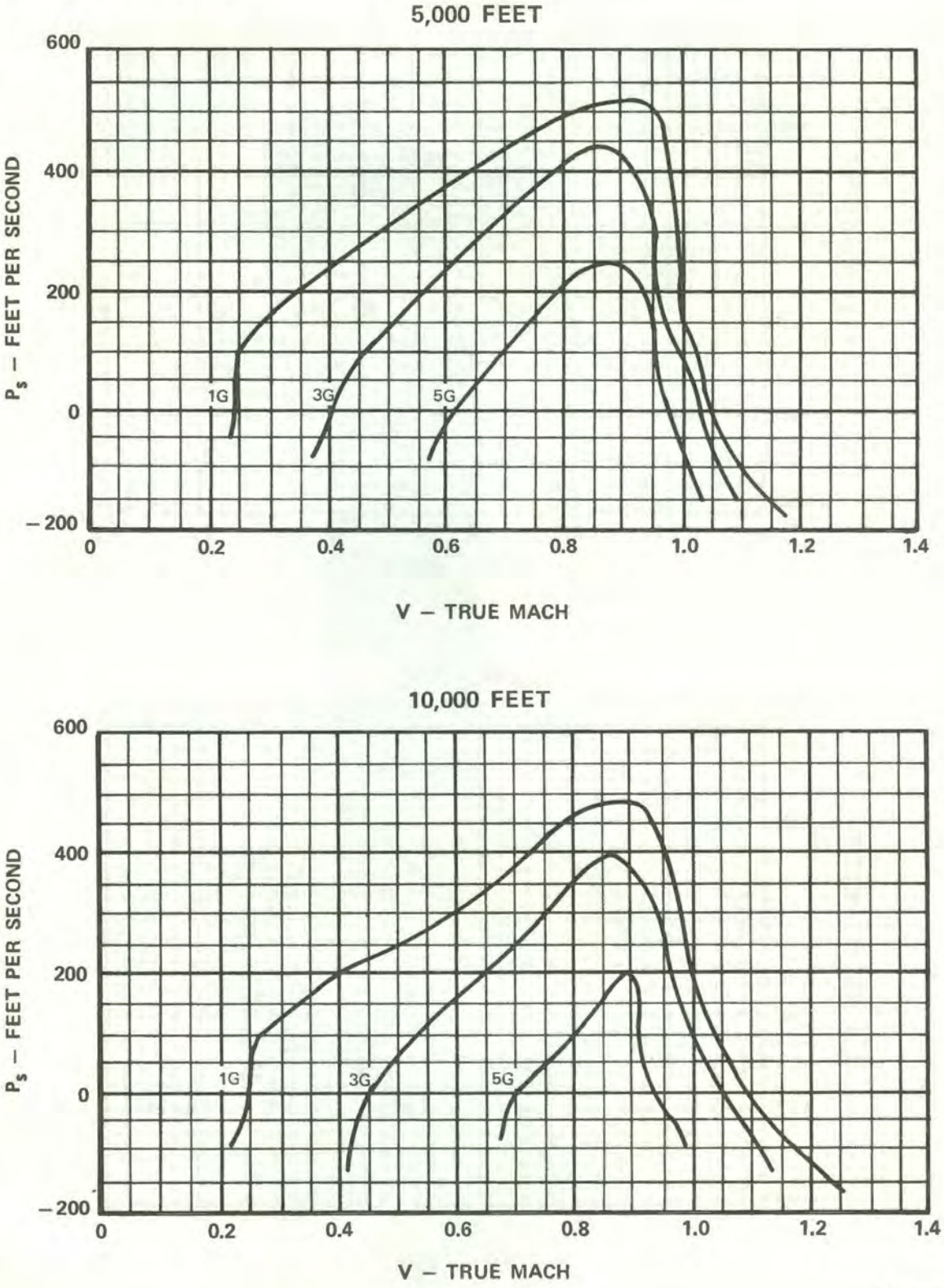


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Figure 1-24 (Sheet 4)

P_s-V Diagram

F-8E, MAXIMUM POWER

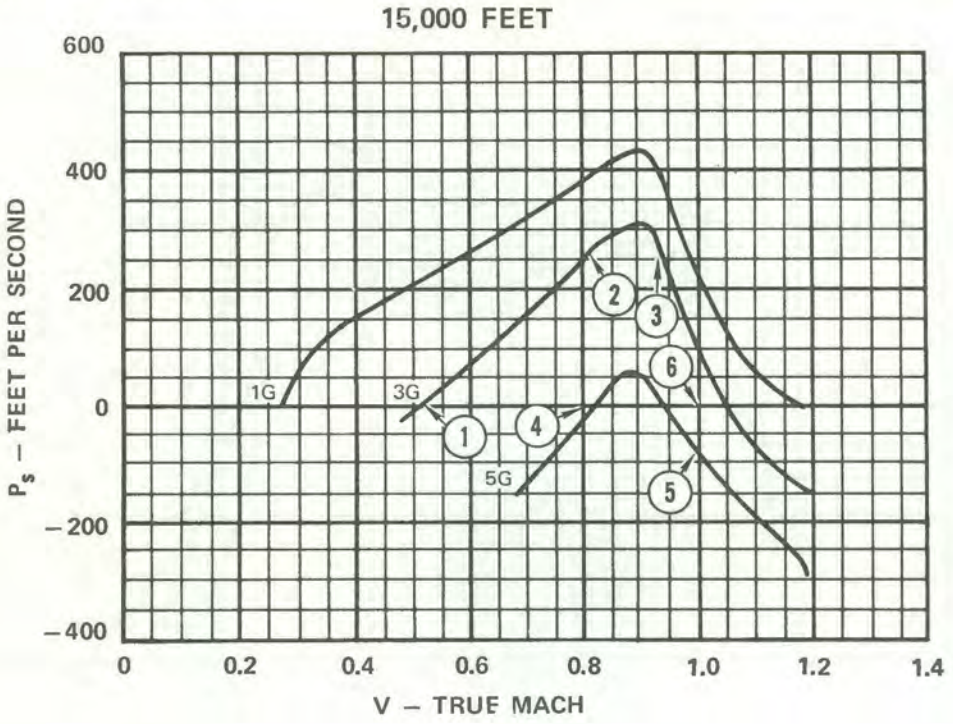


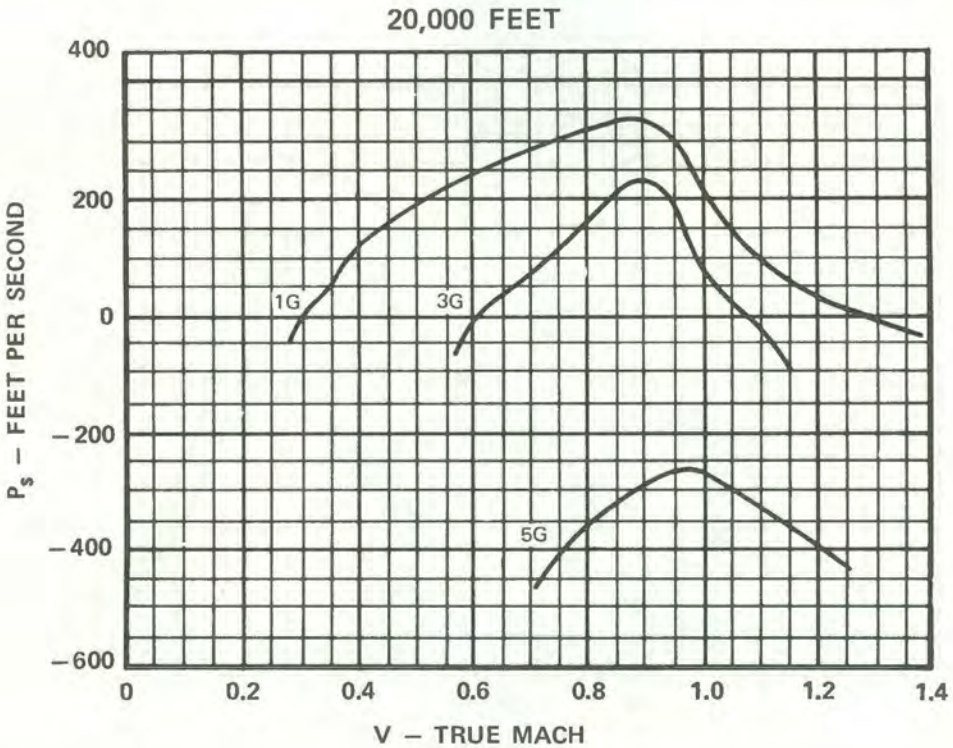
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Figure 1–25 (Sheet 1)

P_s-V Diagram

F-8E, MAXIMUM POWER





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Figure 1–25 (Sheet 2)

P_s-V Diagram

F-8E, MAXIMUM POWER

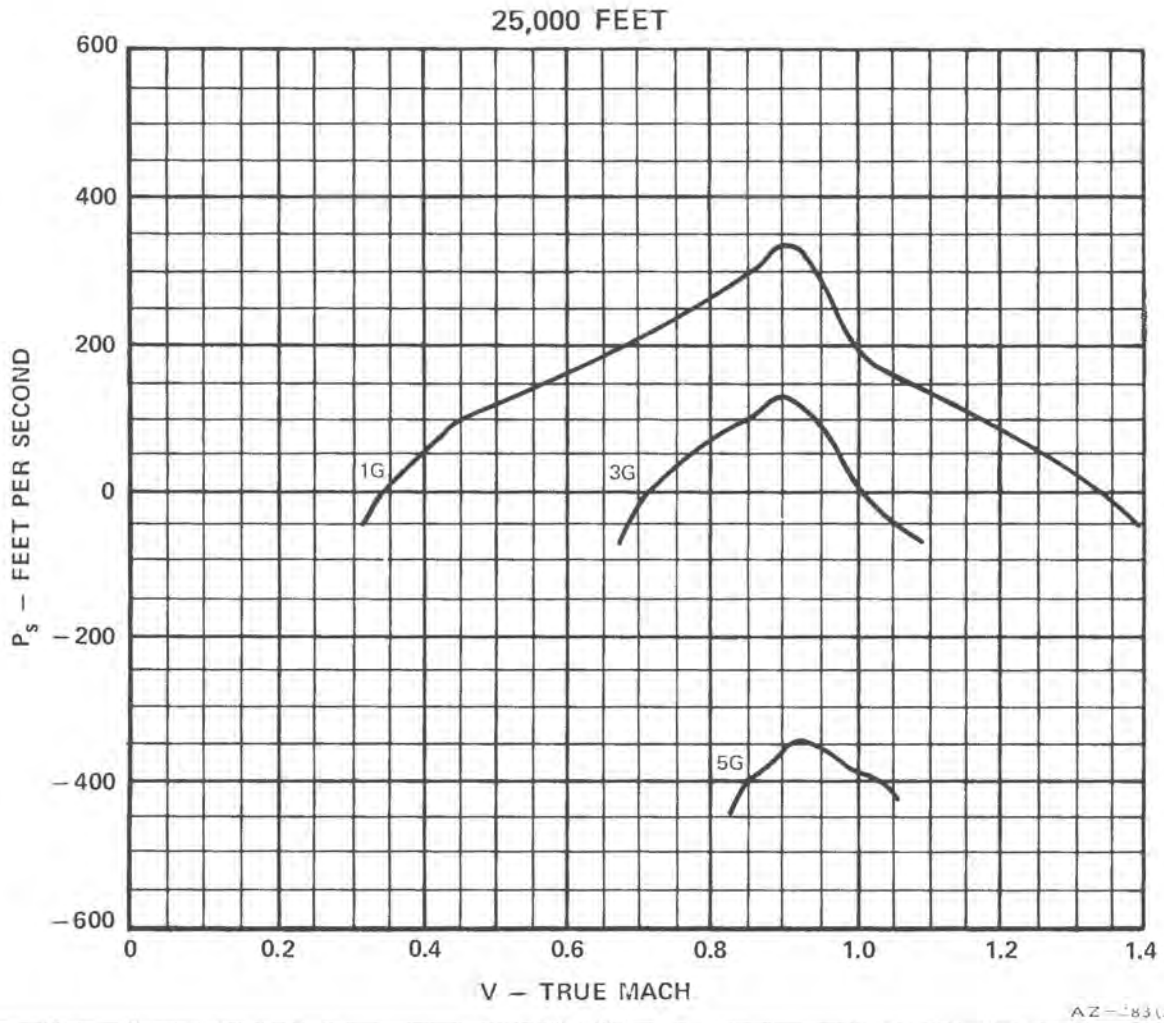


Figure 1–25 (Sheet 3)

unit of E_s is feet. Any "level" of specific energy, E_s, may be plotted on a graph of altitude-versus-velocity as a parabola (figure 1–26).

Note on figure 1–26 that an E_s of 15,000 feet (zero airspeed) can theoretically be transformed into 0.53 Mach at 10,000 feet (Position No. 1); 0.73 Mach at 5,000 feet (Position No. 2); or 0.88 Mach at sea level. Conversely, an aircraft in level, 0.88 Mach flight at sea level can, in theory, "zoom" to 15,000 feet and zero airspeed (no engine power increase).

Figure 1–27(1) is an actual H-V diagram for an F-8E under MRT power and 1g conditions. Constant P_s lines are depicted indicating the rates of climb in feet per second that an F-8E would be capable of at any airspeed/altitude combination shown. For an example of figure 1–27(1), at 0.75 Mach, proceed vertically to the 300 P_s contour (approximately 21,000 feet altitude). Note that the 30,000 feet E_s contour also crosses the 300 P_s contour at this same point. This means that an F-8E at 0.75 Mach and 21,000 feet at MRT in 1g flight can initiate a climb at 300 feet per second or, theoretically, zoom to 30,000 feet (zero airspeed) with no engine power increase.

Referring to the crosshatched area on the lower right edge of figure 1–27(1), note that a 30,000 feet E_s line can, in theory, be transformed into 1.25 Mach at sea level. However, check the zero P_s curve. The zero P_s curve forms the envelope within which an aircraft can maintain level 1g flight. Consequently, an F-8E can never transform an energy level of 30,000 feet into an equilibrium sea level Mach 1.25.

Note

The E_s curves on the H-V diagrams are based on a "perfect atmosphere" (i.e. no drag). In actual practice, however, this can be neglected when comparing H-V diagrams. Since the P_s curves of aircraft being compared are superimposed over the same E_s curves, the errors introduced will, for our purposes, cancel each other out.

APPLICATION

Obviously, the most beneficial use of Energy Maneuverability will be in the area of comparing the F-8 with enemy fighter aircraft. Comparisons covering all situations are beyond the scope of this manual, but with a basic understanding of the principles above, the fighter pilot will be able to determine how and in what regimes he can successfully engage the enemy. The following example illustrates one way energy maneuverability can be used. The example makes use of actual F-8 H-V diagrams.

Although an aircraft has the same energy anywhere on the same E_s contour such as ABCD of figure 1–27(1), not all points on such a contour are equally desirable. Points near B require such a high angle of attack for 1g flight that drag is relatively high. As point B is approached from the right, the increasing drag reduces P_s to zero and no power is available to increase energy. P_s also decreases as one progresses from C to D because of the increase of drag with airspeed and air density. The most advantageous point to be with an E_s of 30,000 is point C. This is a point of tangency of a P_s contour (interpolated) with the E_s = 30,000 curve. Study of the diagram shows that no other point on the chosen E_s curve has such a high P_s available for increasing energy. It follows then that the highest energy level for a given P_s is the point on the P_s curve at which the nearest E_s curve is tangent to this curve. Interpolation of E_s and/or P_s curves may be necessary to find this point.

Note

At zero airspeed, E_s is equal to H (altitude). To avoid confusion, it should be noted that the vertical axes on most H-V diagrams are labeled H and E_s.

The dotted curve in Figure 1–27(1) connects to optimum points on the E_s contours into an optimal path for gaining energy in the least time. An approximation is involved in that the P_s profiles are based on 1g flight and do not strictly apply to an aircraft changing energy. However, an aircraft gaining energy at the rates commonly available is not thought to depart from 1g enough to seriously affect the results. A second approximation of this method results because exact adherence to the optimum profile will in practice result in significant g loadings during the fairly rapid changes in pitch angle sometimes required. In order to avoid high g loadings which are wasteful of energy, it is often necessary to arbitrarily smooth the optimum energy rate paths which are determined from 1g conditions.

Studying figure 1–27(1) (F-8E under maximum power) it is seen that the F-8E should attain and hold approximately 0.9 Mach until reaching about 40,000 feet. A

H–V Diagram

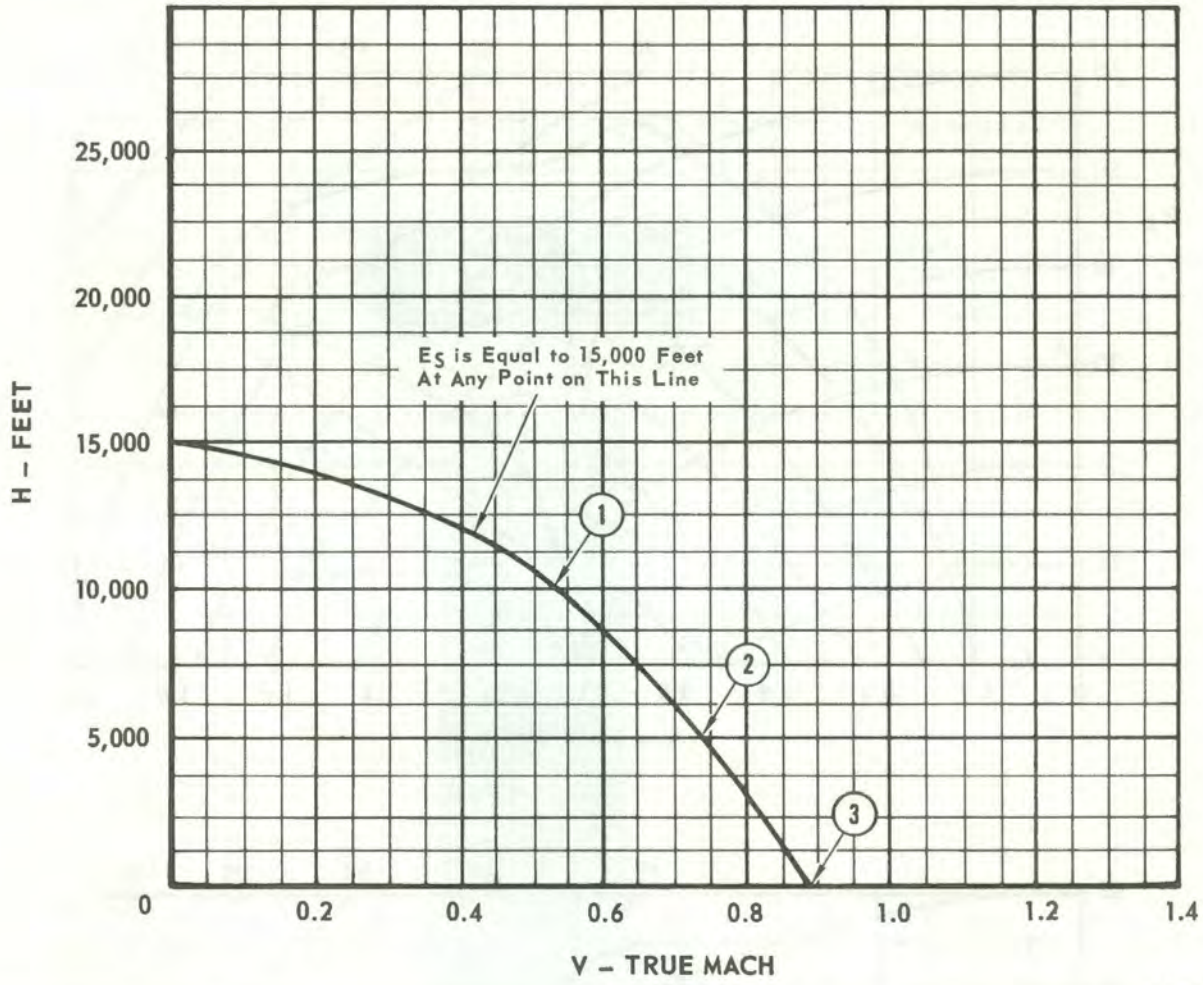
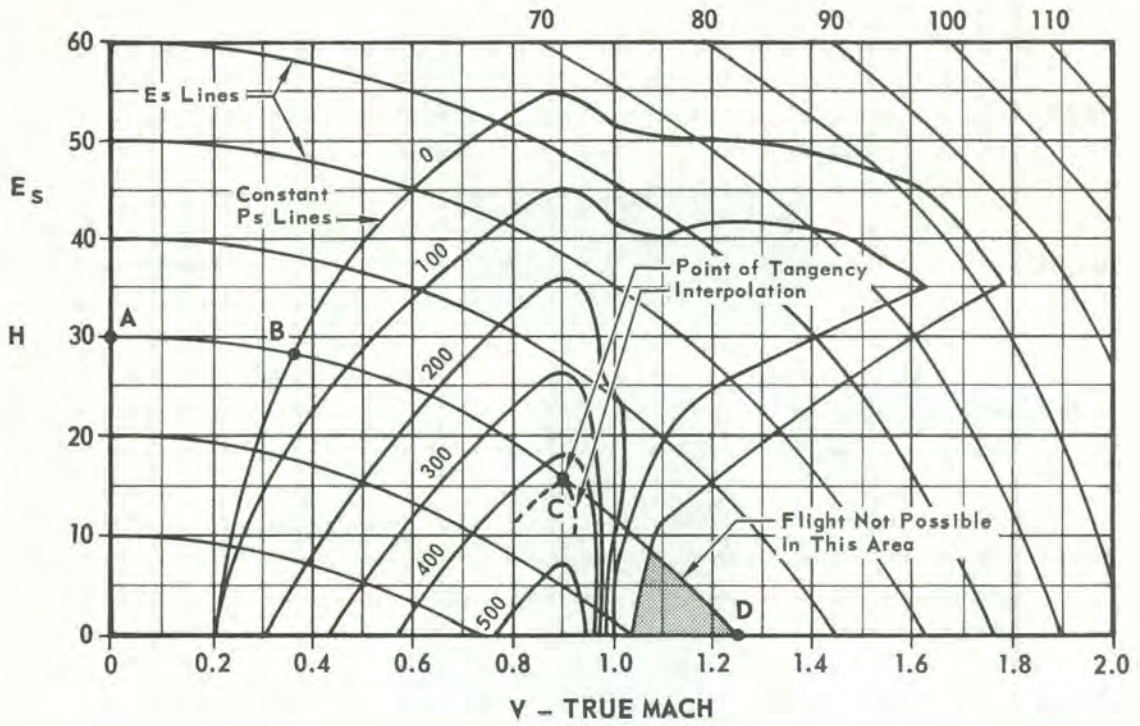
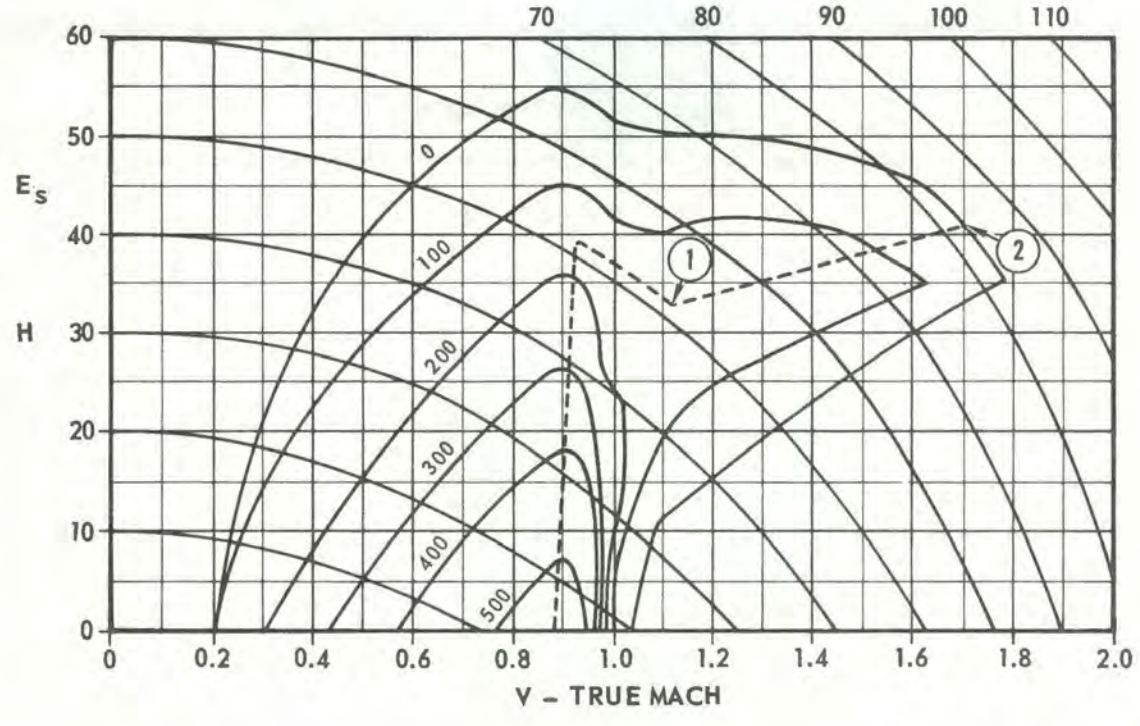


Figure 1–26

F-8E Maximum Power 1G Energy Rate Diagram

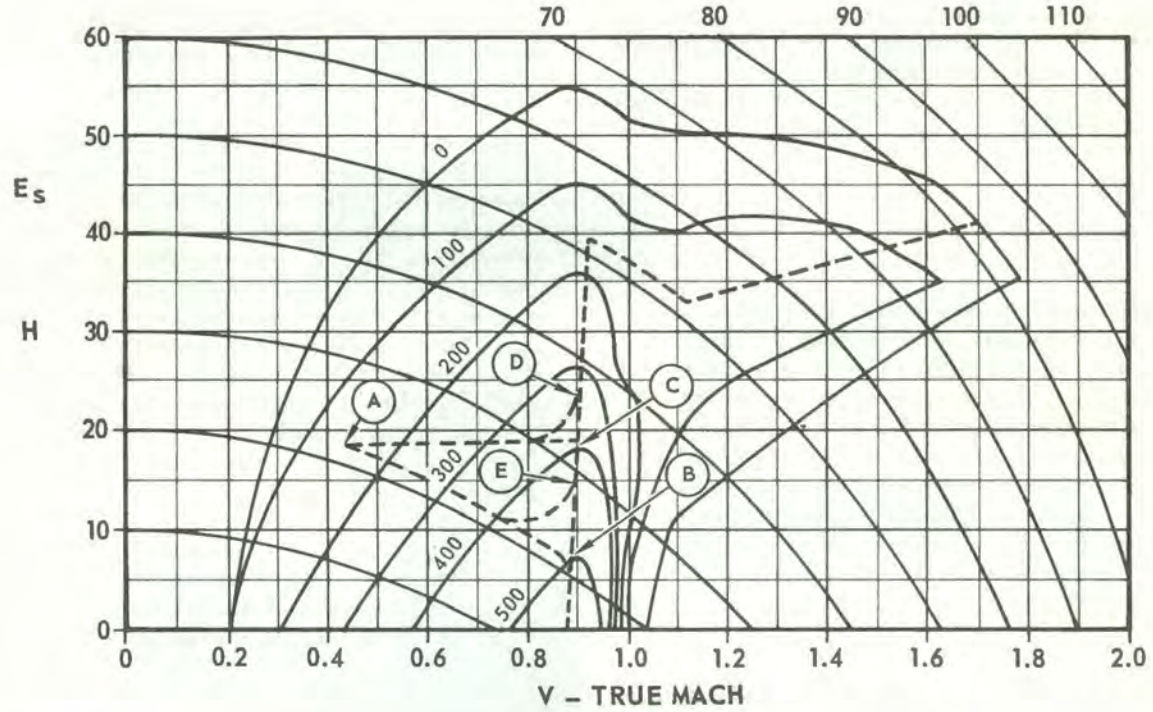


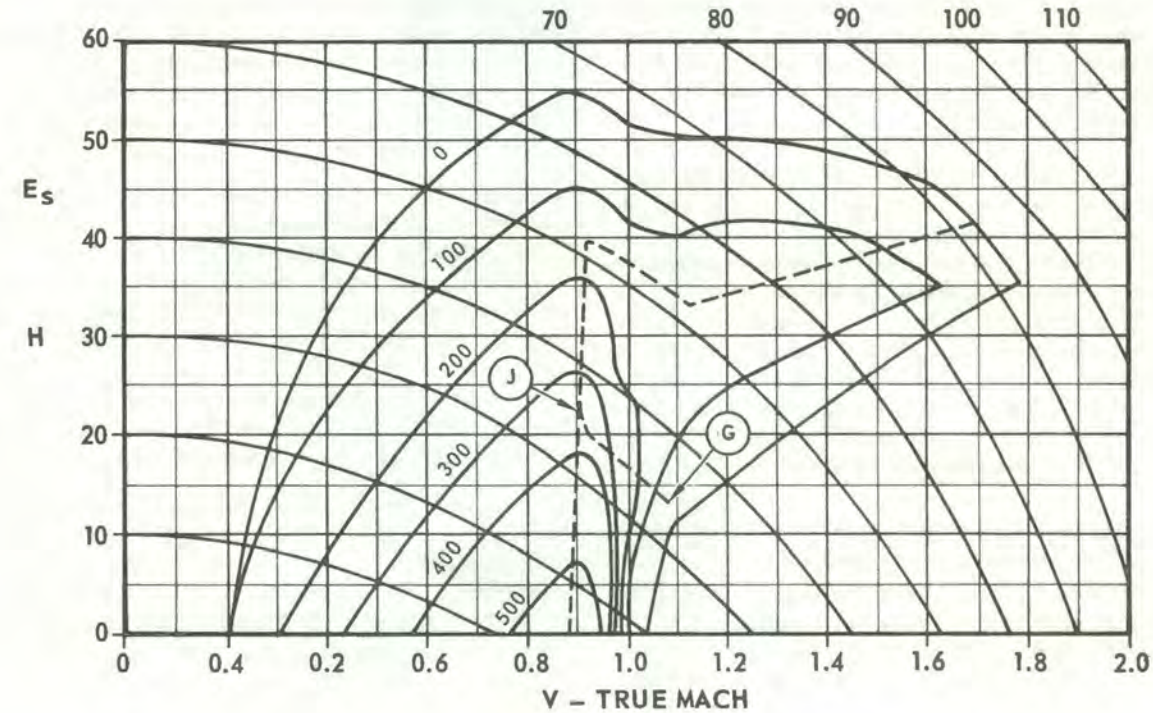


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Figure 1-27 (Sheet 1)

F-8E Maximum Power 1G Energy Rate Diagram





AZ-285(2)-5-68

Figure 1–27 (Sheet 2)

slight descent is then started to approximately 33,000 feet by flying in a parallel path between the 50,000 feet E_s curve and the 60,000 feet E_s curve to point one.

(Note that the 100 feet/second P_s curve "bulges" out to the right toward higher E_s (energy) levels. Since the 200 feet/second P_s curve does not, rough interpolation will show that the 150 feet/second P_s curve will reach out to point one.) The flight path is then continued out to point two, the maximum energy level of 83,000 feet E_s.

Note

The flight path just described is the optimum, minimum time flight path to reach the maximum energy level. It also must be noted that this airspeed (1.8 Mach) occurs at any energy level of 83,000 feet. If this E_s is expressed solely as altitude, it exceeds the maximum altitude actually attainable. The F-8E can only be "zoomed" to approximately 68,000 to 70,000 feet as compared to the theoretical "zoom" associated with the maximum energy level (83,000 feet).

The H-V Diagram may also be used to determine the maximum airspeed available at each altitude. To find this airspeed, proceed horizontally at a selected altitude, to the right edge of the zero P_s curve. Rates of climb available to an F-8E on the climb path just described can be read directly from the P_s lines. Referring to figure 1–27(1), an F-8E will climb 300 feet/second at 27,000 feet, 200 feet/second at 36,000 feet and 100 feet/second at 45,000 feet.

Although the speed-evaluation trade-off path for maximizing energy rate has been described above and illustrated in figure 1–27(1), the best procedure for getting onto this path when starting from an arbitrary point has not been discussed. Therefore, consider an F-8 located at point A of the H-V diagram of figure 1–27(2). Let the objective be to increase energy as fast as possible, and the needed information is how to best join up with the optimal energy rate path. Two profiles for this purpose are easy to portray on an H-V diagram. The two possibilities are:

a. Acceleration at constant altitude (AC in figure 1–27(2) until the optimal path is reached.

b. A dive which carries the F-8 along the initial E_s contour until intersection with the optimum path is made (AB in figure 1–27(2). (The steepness of the dive will not affect the path as presented on the H-V diagram as long as departure from 1g coordinated flight is not serious. The steepness of the dive will affect the time required to traverse from A to B). In all cases, as the speed dictated by the optimal path is approached, the aircraft pitch angle should be increased such that the pilot eases onto this path at the specified speed and climb rate. This will prevent an overshoot in speed or the need for a high g pullup.

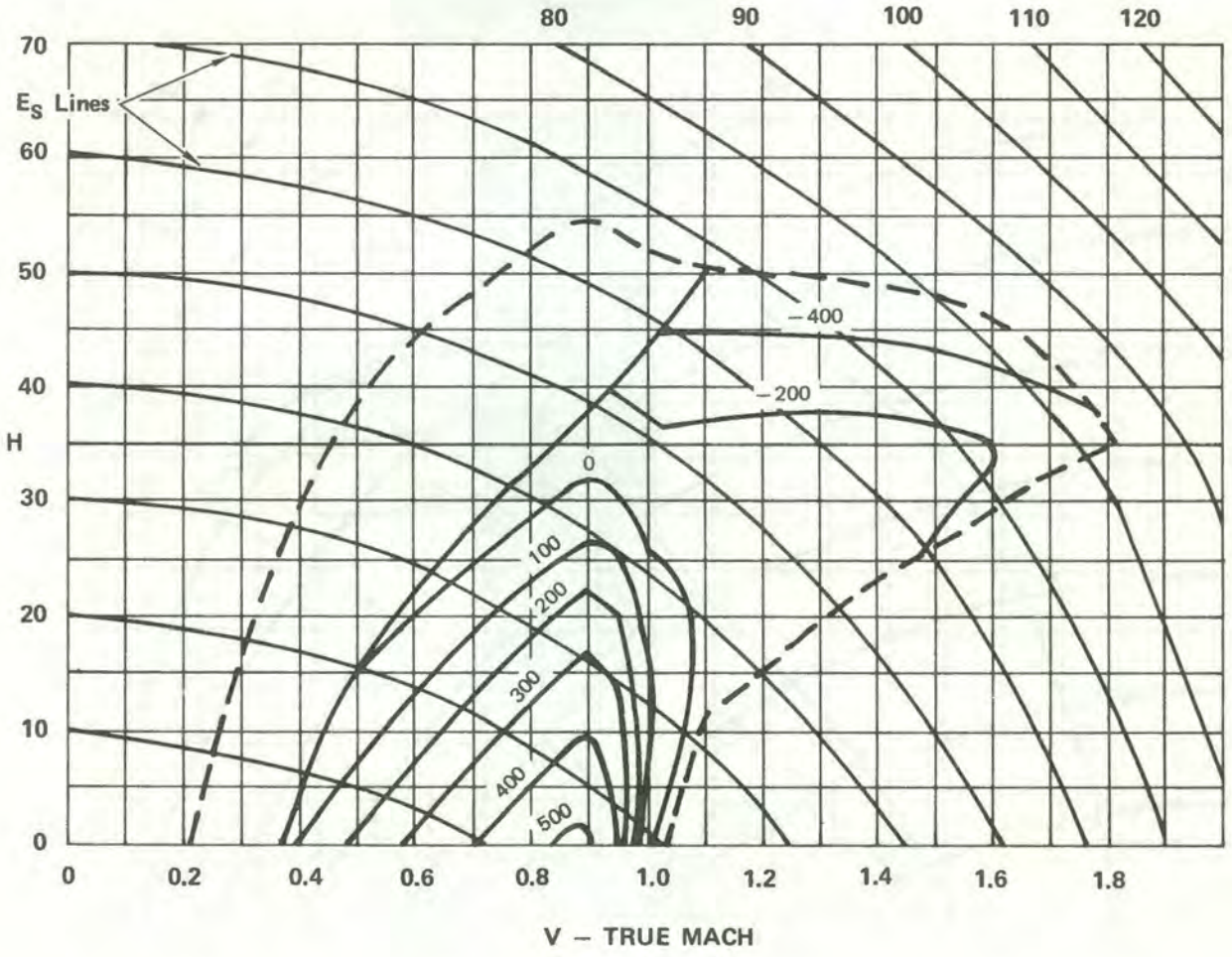
Case 1 has been criticized because it results in crossing E_s contours at other than the point of maximum P_s. However, this does not necessarily negate successful maximization of average P_s over time which is the objective. In Case 2 exact traversal of the constant E_s contour will require a constant throttling back as any positive P_s will move the aircraft off the E_s path. This procedure is surely wasteful because P_s will be kept at zero until an altitude-airspeed configuration on the optimal path is attained. Since this problem has not been solved analytically for the general case, there is no preferred path from theoretical computations from an arbitrary initial point.

A reasonable procedure in practice for maximizing energy rate from an arbitrary point such as A is the following. It is assumed the pilot knows what his airspeed should be for best energy gain for his altitude. The pilot goes to full power and notes his speed and acceleration. If these quantities indicate he is rapidly approaching intersection with the optimal path, it is necessary merely to establish the rate of climb required. If the acceleration is slow, lower the nose, accelerate, and intersect the optimal path. Entry and pullout requiring high g must be avoided and should smoothly terminate with the correct pitch angle established. If no dive is required, the resulting path will resemble AD of figure 1–27(2) whereas a dive will result in a path such as shown as AE.

For an aircraft that is initially on the high speed side of the optimal path such as point G of figure 1–27(2), the procedure is somewhat different. Here a climb is required to bring the speed down to the value specified for best energy rate. On the H-V diagram a practical profile for this procedure will qualitatively resemble GJ. The exact trace will depend on pilot judgment. His climb rate must exceed his P_s or his speed will increase rather than decrease. Figures 1–27A and 1–27B depict the F-8E under maximum power at 3g and 5g.

With this basic understanding of energy maneuverability the fighter pilot can now refer to "Energy Maneuverability" (U), APGC-TR-66-4, Volumes I, II and III, published by the Air Proving Ground Center (PGTO), Elgin AFB, Florida. These publications contain appropriate V-n and H-V diagrams for United States and potential enemy aircraft.

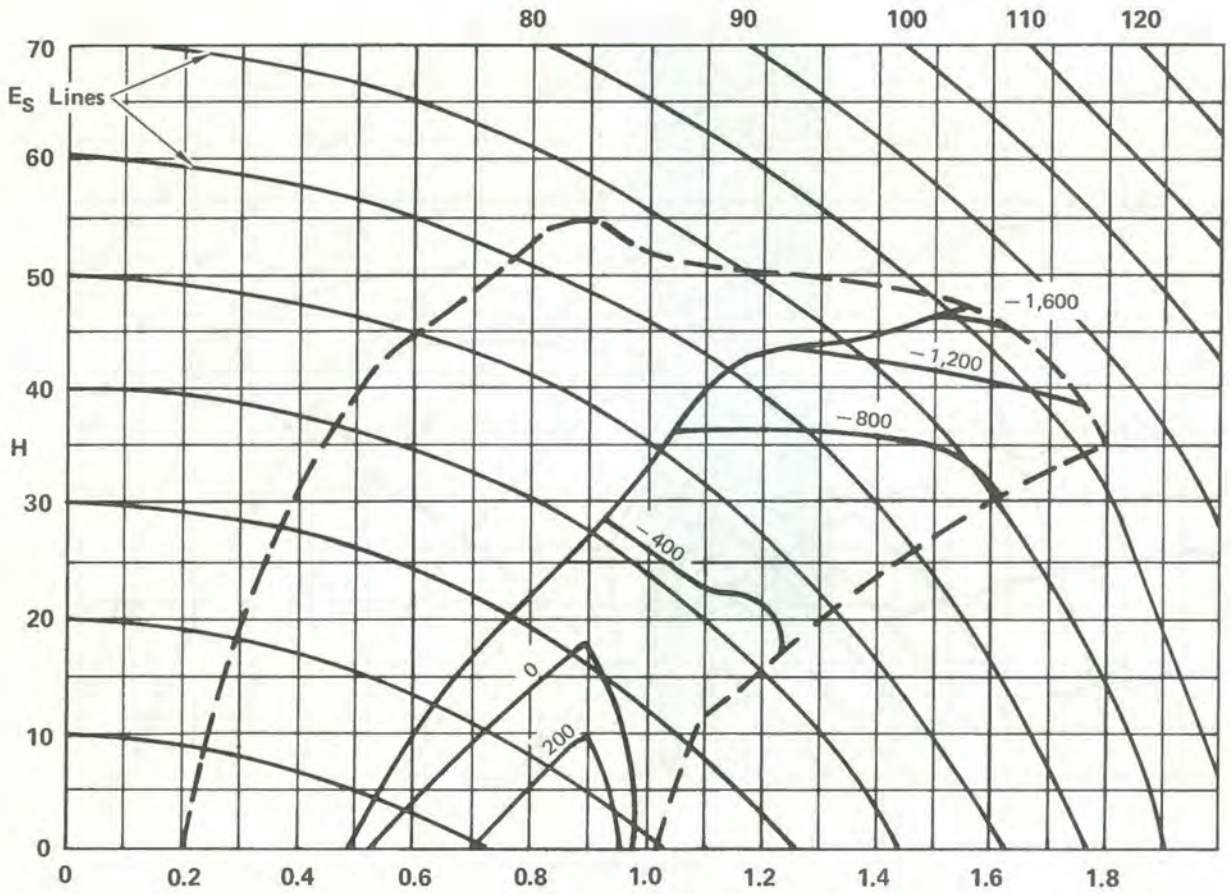
F-8E Maximum Power 3G Energy Diagram



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Figure 1-27A

F-8E Maximum Power 5G Energy Diagram



AZ−331−03−69

Figure 1–27B

Like other professional men, fighter pilots must learn from those who have gone before them. The following books have been written by experts in the field of fighter aviation. They are required reading for the professional fighter pilot and are a must for your Wing/Squadron professional library.

1. G. Boyington, *BAA BAA Black Sheep,* G. P. Putnam's sons, New York
2. Adolf Galland, *The First and The Last, The Rise and Fall of the LuftWaffe: 1939-1945,* U205, Ballantine Books
3. E. H. Sims, *American Aces, Twelve Army Air Force Pilots: Their Most Exciting Missions,* U208, Ballantine Books
4. J. E. Johnson, *Full Circle: The Tactics of Air Fighting 1914-1964,* U6012, Ballantine Books
5. Saburo Saki, *Samurai: Flying the Zero in WWII with Japan's Fighter Ace Saburu Sakai.* M. Caldin and F. Saito. U2806 Ballantine Books
6. R. S. Johnson, *Thunder Bolt:* With the Fabulous U.S. 56th Fighter Group–Killer of over 1000 German planes, Martin Caiden, F764, Ballantine Books
7. Yasuo Kowahara and G. T. Allred, *Kamikaze,* U2821, Ballantine Books
8. C. Blair, Jr., *Beyond Courage,* U2209, Ballantine Books
9. J. Bryan, III, *Aircraft Carrier,* 697, Ballantine Books
10. F. Harvey, *Jet,* 691, Ballantine Books
11. E. Trevor, *Squadron Airborne,* U2223, Ballantine Books
12. H. U. Rudel, *Stuka Pilot,* U2136, Ballantine Books
13. E. H. Sims, *Greatest Fighter Missions,* X744, Ballantine Books
14. Paul Brickhill, *The Dam Busters,* U2813, Ballantine Books
15. Robert L. Scott, *God is My Co-Pilot,* 145, Ballantine Books
16. Pierre Clostarmann, *The Big Show,* Ballantine Books
17. Martin Caiden, *Zero,* Ballantine Books
18. Martin Caiden, *Torch to The Enemy,* Ballantine Books
19. B. S. Kelsey, "There'll Always Be A Fighter" reprinted from *Cockpit,* July, 1965, The Society of Experimental Test Pilots
20. Fighter Weapons Newsletter, *No Guts–No Glory*

PART 2 — COMBAT AIR PATROL

BRIEFING REQUIREMENTS

Effective employment of the F-8 as CAP depends upon comprehensive briefings which include, as a minimum, the following:

a. Weather and Associated Effects.

1. Weather in Task Group operating area
2. Weather at CAP station, possible combat intercept areas, and divert fields
3. Wind conditions at altitude
4. Sea state
5. Ducting levels
6. Contrail levels
7. Ambient temperature vs altitude

b. Task Group Operational Considerations.

1. Probable early warning ranges and height finding capabilities in all sectors and all altitudes
2. Surface-to-air missile (SAM) zone limits (friendly and enemy)
3. Fighter exclusion zone limits
4. Task Force/Group formations and dispositions
5. Position of carriers in Group for each formation
6. Point of intended movement (PIM) variations
7. Control of electromagnetic radiation (EMCON)
8. Specific identification (ID) policy regarding:
   Electronic ID — identification, friend or foe (IFF), passive receiver analysis, etc.
   Kinematic ID — target altitude, speed, heading, and turns
   Geographic ID — target position in corridors, etc.
   Visual ID — whether targets must be visually identified in specific cases
9. Air control assignment
10. Communication frequencies and calls
11. Authentication procedures
12. Navigation aid guard ships (positions and operating times)
13. Selective identification, friend or foe (SIF) code messages for radio failure and communications ECM

c. CAP Station Assignment.

1. Sector or loiter pattern
2. CAP relief point
3. Policy for major weapon system deficiencies
4. Search responsibility in CAP loiter pattern
5. Combat fuel allowance (total fuel for intercepts)
6. Cycle time (time from catapult to arrestment)
7. Friendly field availability and location
8. Ready deck information
9. Airborne tanker provisions
10. Emergency ejection instructions

d. Intelligence Information.

1. Likely direction of raid approach
2. Types to be expected and relative numbers of each type
3. Altitude/Mach number and pertinent performance data typical of each type
4. Typical formation expected (close, stream, or wide, etc.)
5. Identity features of each type
6. Armament of each type
7. Weapons loading typical of each type (bomb trajectory or stand off)
8. Bomb release line for typical weapons
9. Radar reflective area of each type
10. IR detection range for each type
11. Typical defensive and offensive tactics
12. ECM capabilities of each type

e. Search and Rescue Information.

1. Disposition of SAR forces
2. SAR frequencies
3. SAR capabilities
4. Safe areas
5. Escape and evasion information

PROCEDURES

Prelaunch procedures are in the NATOPS Manual. EMCON conditions and ordnance proximity may modify radar operating procedures.

Under most conditions an MRT climb should be used enroute to the CAP station. The MRT climb will allow for timely CAP relief and affords maximum fuel after reaching the station.

The maximum on station time will be obtained by climbing straight ahead without turns. Excess turns, depending on where they are made in the climb, may shorten on station time as much as five to ten minutes. If the CAP is assigned a low-far or long-range station, the run-out profile selected should be the best compromise between time enroute and cycle time.

The pilot should adhere to the recommended climb schedule. If a turn has to be made before reaching CAP altitude, less fuel will be wasted if it is accomplished

just after launch at moderate power or later at very shallow angles of bank. Low altitude rendezvous and section climb-out costs heavily in fuel and should be avoided if possible.

The weapon system should be checked soon after launch. Normally CAP relief can only be considered complete when on station with the airplane and weapon system checked out satisfactorily.

Once CAP airspeed and altitude are established, endurance is of major importance. A prime consideration is the angle of bank used in maintaining CAP station. Reduced fuel consumption is obtained by flying the aircraft near the minimum thrust required airspeed using low bank angle turns. When an airplane is banked, its load factor and apparent gross weight increase. In order to maintain balanced flight, angle of attack or airspeed must be increased. Either action results in drag increases, which require more thrust and fuel. The normal reaction is to add an increment to the maximum economy speed to permit turns without entering the back side of the drag curve. The greater the increment selected, the higher the excess fuel flow. If low bank angles are used, this added speed increment can be reduced. However, when the airplane is flown at maximum endurance airspeed, rough bank and altitude control can easily result in entry into the high drag region. The fuel consumed in accelerating back to loiter speed may equal or exceed the original fuel saved. Therefore, a minimum-fuel loiter pattern must be flown with extreme precision.

As an example, at 35,000 feet with a 270 KIAS and fuel flow of 2,700 lb per hour, a 20-degree angle of bank will increase fuel flow 150 lb per hour. At 30 degrees angle of bank, it will increase about 300 lb per hour. If tactically feasible, 15-degree angle of bank is recommended. This will increase fuel flow approximately 100 lb per hour. Use of the autopilot can be of great assistance in maintaining a precise loiter flight speed.

Obviously, the selection of a higher than maximum economy loiter speed is justified, if the CAP is stationed in an exposed area where it might be attacked. In this case, the loiter speed selected should allow for tactical maneuvering.

Note

If the CAP pattern or area is limited such that it requires bank angles in excess of 15 degrees and a reasonable chance exists of being vectored for a bogey, maximum range cruise airspeed is recommended.

CAP PATTERNS

There are three basic CAP patterns which may be modified to meet specific requirements.

The oval CAP pattern is best from an endurance standpoint since turning flight is at a minimum. It should be oriented perpendicular to the direction of the expected threat. At mid and low levels it may be advantageously employed using vertical in place turns to reduce the time in turning flight.

The figure eight CAP pattern allows the pilot a turn of less than 135 degrees for bogey vector from any point in the pattern. It costs more fuel than does the oval pattern because of the added time in turning flight.

The rectangular CAP pattern is similar to the oval except that a wings level cross leg is flown at each end of the pattern. It is generally used at night and in weather when the CAP section is flying in radar trail.

SPECIALIZED CAP

TARGET CAP

TARCAP is used to provide close-in protection of friendly attack aircraft. TARCAP is flown with either one or two F-8 sections. The TARCAP aircraft may be required to cover the attack group during its run-in and retirement from the target by flying the F-8 sections above and behind, weaving as necessary to maintain fighting speed. Over the target areas, the F-8 sections maintain clearance behind the strike element to counteract any threat from enemy aircraft. Airspeed is maintained between 400 and 450 KIAS. Section lead will maintain radar and visual lookout, while the wingman maintains formation and visual lookout. TARCAP will be at an altitude so as to maintain visual contact considering weather and enemy defenses. Should enemy air opposition develop, the resulting mix of friendly and enemy aircraft may rule against use of air-to-air missiles. Guns should be used as the primary weapon in such a situation. All TARCAP aircraft should be tanked enroute to provide maximum fighting fuel in the target area.

BARRIER CAP

BARCAP is stationed between friendly aircraft and the expected threat. In particular instances it is useful to establish selected and number-designated geographic holding points. This information is passed to the controlling agency so that flights may be positioned at any specific point they request without compromising their intentions. If more than one section is available, the sections can be stationed in mutually supporting positions, although not necessarily in visual contact. Normally the BARCAP checks in, is identified, and is then tracked throughout the flight by a destroyer or by airborne AEW aircraft. BARCAP aircraft should be tanked enroute to provide maximum fighting fuel in the BARCAP area. At night the section maintains altitude separation and either a radar trail formation or an individual tactical pattern relative to a preselected TACAN position. BARCAP must be under positive control when flown at night or in IFR conditions without visual reference to land or sea.

PART 3 — ESCORT

Escort missions provide defense for aircraft whose capabilities for a particular mission preclude self defense. Escorted aircraft include helicopters, attack, reconnaissance, ELINT and AEW aircraft.

ESCORT TACTICS

Formations used during the escort mission must fulfill the requirements of maneuverability, simplicity, effectiveness of lookout, mutual support and concentration of firepower.

The variables which enter into the selection of the best tactical formation are too numerous and too dependent upon the combat environment to classify any specific formation as the best for all situations. The formations discussed are basic and adaptations to meet differing conditions must be made.

The loose deuce formation described in Section I is designed to provide the best lookout coverage, especially in the area astern, and to keep the formation in the best relative position for mutual support in event of attack by enemy aircraft.

LIGHT ATTACK (JET)

The mission of light attack squadrons is to conduct air-to-surface operations. Mission profiles used are determined by many variables. Some of these are: range, fuel consumption, type target, ordnance load, enemy radar coverage, and probability of enemy airborne fighters. Compatibility of the F-8 with light attack profiles is excellent. Normal attack profiles fall into three categories:

a. Entire flight at low altitude.

b. Entire flight at high altitude.

c. Initial portion of flight at high altitude, and remainder of flight to target at low altitude.

Position of the fighter escort will depend upon the number of attack aircraft to be protected, expected air threat, and the visual protection envelope. Varying the position of the fighter escort may increase or decrease the protection envelope depending upon the flight conditions encountered. In varying the position of the fighter escort, the visual mutual protection envelope must be kept in mind at all times. One practical method of escort employment is to station sections of F-8s at 4 and 8 o'clock. If a high enemy air threat is anticipated, an additional section may be positioned at 6 o'clock. Sections should be 1 to 2 thousand feet higher and 6 to 9 thousand feet from the attack group. Positions may be maintained by flying either co-speed or weaving when higher airspeeds are desired. Caution should be exercised when weaving that overall escort effectiveness is not degraded. An instance where a heavy-sided formation might be more advantageous is where the expected air threat is known to be limited to an attack from one direction. In all cases (consistent with EMCON conditions), the F-8 pilot should use the radar to increase detection ranges and to augment visual coverage.

F-8s may be utilized as escorts for Shrike carrying aircraft to provide lookout for SAMs and protection against enemy air attack. Due to the high SAM exposure, only the most experienced squadron pilots should be used. Escort should fly in a 60° cone oriented on the Shrike aircraft with approximately 1,000 feet altitude differential and 1,000 to 1,500 feet behind. This provides an area large enough in which to maneuver and yet close enough to provide excellent lookout protection. CRT may have to be used periodically to maintain position in SAM evasive maneuvers.

LIGHT ATTACK (PROP)

Escorting propeller aircraft has many inherent problems. The most readily apparent are the differentials of speed, fuel consumption, and turning radii. The combat spread formation may be used during escort provided the distance between wingmen is increased to the full turning diameter of the F-8. Generally, the F-8 is limited when providing TARCAP and/or BARCAP for propeller attack aircraft.

HEAVY ATTACK

The mission of heavy attack squadrons is to conduct air-to-surface, all-weather operations. Because of the long range capability of heavy attack aircraft, the escort mission by the F-8 becomes limited. The procedures regarding lookout doctrine and formation

employment, as described for light attack (jet), also apply when escorting heavy attack aircraft.

PHOTO

A single fighter should be sufficient for photo escort, unless the probability of air opposition dictates the use of a section. The single aircraft may either be flown in a combat spread on the photo plane or in a tactical wing formation. The escort has the responsibility to provide lookout and assist in navigation where possible. If a section is used, it should be flown in combat spread or a maneuvering tactical wing formation on the photo plane. On low altitude missions the escort should stay above effective small arms fire. When escorting the R-F8, performance data of the F-8 should be used for mission planning to insure adequate fuel specifics and performance.

HELICOPTER

The pattern for helicopter escort is a racetrack or modified oval shape (inverted dish), with equal intervals between aircraft around the pattern. Each escort aircraft will pass close abeam of the helicopters on the flight base heading in a dive of about 30 degrees, observing the terrain below and ahead of the flight for hostile fire and enemy positions. The descending portion will extend about one mile ahead of the lead helicopter down to a minimum prescribed altitude AGL. A climbing turn is made to about 3,000 feet above the altitude of the helicopter to a reverse heading. Each escort aircraft will be about a mile-and-one-quarter abeam on the reciprocal leg. A level turn is made back to base heading from the beam position, with the entry into the dive commencing before establishing the base heading. Escort aircraft must keep visual contact with each other. Two or four escort aircraft can operate in the pattern effectively when covering flights of up to 12 to 15 helicopters. This will provide for an escort aircraft to be in a run-in position to start a run at any time. The average speed in the pattern will be about 300 knots, with power essentially constant. Altitude variations and pattern size and shape may be modified when low ceilings dictate. There should be at least 500 feet between the helicopters and the ceiling. A ceiling of at least 2,000 feet AGL and a visibility of five miles is necessary for effective escort of helicopters.

PART 4—INTERCEPT TACTICS

" . . . only the spirit of attack born in a brave heart will bring success to any fighter aircraft no matter how highly developed it may be."

Adolf Galland
Commander, Fighter Forces
Luftwaffe

Although Galland's words are of a different age of fighter warfare, they are none the less true today. The strategically defensive, but tactically offensive, role of the fighter aircraft has not changed. Successful interception of an enemy raid and its subsequent destruction is a primary mission of the fighter pilot and his aircraft, be they enemy bombers, fighters or air-to-surface missiles. The versatile Crusader with its primary armament system, the fighter pilot, and a variety of weapons can accomplish this mission. It is the purpose of this section to explore in detail the techniques required to position the F-8 in the best launch envelope for the weapon carried.

BASIC RADAR FUNDAMENTALS

INTRODUCTION

The term RADAR was coined by the U. S. Navy in 1941 by combining the words RAdio Detection And Ranging. The word is now commonly applied to electronic equipment used to detect the presence of objects and to determine their direction, altitude and range by means of reflected radio waves. An understanding of the basic fundamentals is mandatory prior to commencing in depth radar training.

RADAR DEVELOPMENT

The development of radar into the highly complex system known today is the accumulation of many developments and refinements contributed from many nations. While the development of radar as an operating system goes back only to 1928, the general principles have been known and used for a long time.

Many discoveries were necessary before a useful system was realized. Some of these are listed as follows:

a. The reflection of radio waves by certain types of objects.

b. The formation of these waves into a beam.

c. The measuring of distance by timing the travel of a radio wave.

d. The detection of the reflected wave.

e. The pulse method of measuring distance.

The final step was the combining of these discoveries into an operating device. Not until the last step was radar invented in the strictest meaning of the word, but since this last step depended upon all the preceding steps, credit must be given to all who participated in the invention.

RADAR IN WORLD WAR II

World War II played a large part in the development of radar in that it speeded up the process by forcing its development as an operating device. Since the nation's security was at stake, very little information concerning radar was made known. The public was aware that there was a marvelous new weapon that had something to do with radio, but beyond that they knew little. This secrecy caused much widespread speculation concerning this new "secret weapon." Many of the tales told were strictly figments of the imagination, but radar did cause many changes in the methods of waging war. In World War II many naval battles were fought at night. Prior to this, no great naval battles were waged in darkness, since you could not shoot at an enemy you could not see. In a typical incident of World War II a new American warship was cruising the South Pacific searching for the enemy. Aboard the American vessel, radar, like an invisible searchlight, probed the darkness and discovered the presence of an enemy vessel more than eight miles away. The big ship lifted its radar synchronized guns and the second salvo, despite darkness and extreme range, landed squarely on the target. This incident would not seem unusual today, but imagine how amazing it was then — for the first time, to have destroyed the enemy without ever having seen him. Such events became common even in the early part of the war.

AIRBORNE EQUIPMENT

The early radar systems were bulky and also weighed considerably more than could be accommodated by the aircraft of the time, but it did not take long to reduce the size and weight to the point where the radar system could be installed in aircraft. Again, the pressing need for superior weapons accelerated the development of airborne radar systems. The early systems installed in aircraft were not nearly as sophisticated as those of the modern day weapon systems, but the radar was a powerful aid to the aircraft. The aircraft also proved to be an aid to the radar since it supplied an elevated platform, thereby extending the effective range at which objects could be detected. The application of radar to airborne operations has been most successful, and airborne radar is an indispensable part of the Navy's fighting team.

Airborne radars are designed to meet the strict packaging limitations that are necessary for all avionics. Even so, airborne radar sets serving many purposes have been designed to produce the same power as shipborne or shorebased units.

In fighter aircraft, the primary mission of radar is to aid in the search, interception, and destruction of enemy aircraft. This requires that the radar have a tracking feature. The fighter radar system must also be capable of providing the necessary inputs to an appropriate fire control system to properly compute and display gun lead and missile firing indications to the pilot. The aircraft, radar, fire control system, and weapons are collectively known as a "weapons system."

PRINCIPLES OF OPERATION

All radars operate using the same basic principles. The transmitted beam of radio-frequency energy is directed over a region of space to be searched. When the beam strikes a reflecting object, energy is reradiated or reflected. A very small part of this reflected energy (the echo) is returned to the radar system. A sensitive receiver detects the echo signal and, therefore, the presence of the object or target. The determination of the actual range and direction is based on the following two facts:

a. Radio-frequency energy travels at the constant speed of light (186,000 statute miles per second).

b. The receiving system can be made directional.

These two facts remain constant regardless of the particular function the radar has been designed to perform. There are other constants associated with each type of radar.

SYSTEM CONSTANTS

Although all radars operate on the same basic principles, each varies according to its function. Associated with any radar are certain constants. These constants are chosen for a particular radar system, depending on its tactical use, the accuracy required, the range to be covered, the physical size, and the problem of generating and receiving the signal.

Carrier Frequency

The carrier frequency is the frequency at which the radio energy is generated. The principal factors influencing the selection of the carrier frequency are the desired directivity of the radiated beam, the desired physical size of the antenna, and the generation and reception of RF energy.

To permit the determination of direction and to concentrate the transmitted energy so that a greater amount of it is useful, the antenna should be highly directive. The higher the carrier frequency, the shorter the wavelength, and hence the smaller the antenna system for a given sharpness of pattern, since the individual radiating element is normally a half-wave in length. For example, the carrier frequency for a radar set intended for airborne use would have to be fairly high so that a small reflector may be used. Some heavy ground radars use frequencies so low that they must have antenna reflectors more than 100 feet long to attain the desired directivity.

Radar Operating Band Frequencies

The range of frequencies designated for radar operation is divided into bands, each designated by a letter. Each band is centered on a certain frequency and wavelength. The center frequency and wavelength for each band is listed below.

BAND	FREQUENCY (megacycles)	WAVELENGTH (meters/centimeters)
P	150 mc	2m
L	1,000 mc	30cm
S	3,000 mc	10cm
X	10,000 mc	3cm
K	30,000 mc	1cm

Radar sets operating in the P and L bands are known as ultrahigh frequency (UHF) radar. Those operating in the S, X and K bands are called microwave radars. Naval fighters utilize X band.

Pulse Shape and Width

In the case of a pulse type radar, the shape and width of the RF pulse influences minimum range, range accuracy, and maximum range. The ideal pulse shape would resemble a square wave having vertical leading and trailing edges. However, available equipment does not usually produce the ideal waveforms.

The factors influencing minimum range are discussed first. Since the receiver cannot receive target reflections while the transmitter is operating, it should be obvious that a narrow pulse is necessary for short ranges. A sloping trailing edge extends the width of the transmitter pulse although it may add very little to the total power generated. Therefore, along with a narrow pulse, the trailing edge should be as nearly vertical as possible. See figure 1–28.

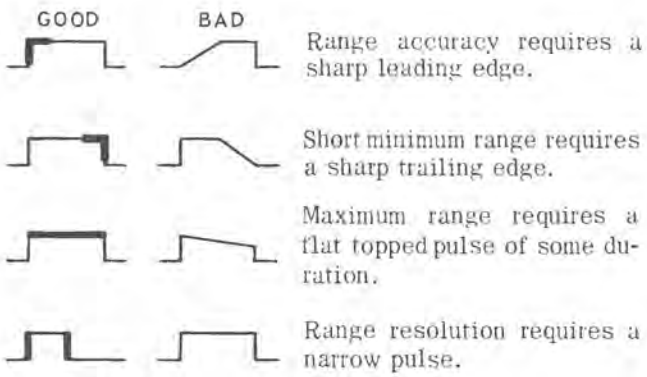


Figure 1-28. Pulse Shapes and Effects

A sloping leading edge also affects minimum range as well as range accuracy since it provides no definite point from which to measure elapsed time. Using a starting point at the lower edge of the pulse's leading edge would increase minimum range. Using a starting point high up on the slope would reduce the accuracy of range measurements at short ranges which are so vital for accurate solution of the fire control problem.

Maximum range is influenced by pulse width and pulse repetition-frequency (PRF). Since a target can reflect only a very small part of the transmitted power, the greater the transmitted power, the greater the strength of the echo that could be received. Thus, a transmitted pulse should quickly rise to its maximum amplitude, remain at this amplitude for the duration of the desired pulse width, and decay instantaneously to zero.

Pulse Repetition Frequency (PRF)

Sufficient time must be allowed between the transmitted pulses for an echo to return from any target located within the maximum workable range of the system. Otherwise the reception of the echoes from the more distant targets may be obscured by succeeding transmitted pulses. This necessary time interval fixes the highest frequency that can be used for the pulse repetition. Both maximum and minimum pulse repetition frequencies for any radar set depend upon the tactical use that is to be made of the equipment. To reach great distances, the radar must be able to radiate plenty of power during the transmission of the pulse, and the rest cycle or waiting time must be long enough to allow the transmitted pulse to travel well beyond the maximum range of the radar and to return.

The time from the beginning of one pulse to the start of the next pulse (this includes the pulse and the waiting time for the return of that same pulse) is the pulse repetition time (PRT). It is the reciprocal of the pulse repetition frequency; that is,

$$PRT \quad \frac{1}{PRF}$$

From this relationship it can be seen that a radar set having a pulse repetition frequency of 1,200 pulses per second has a pulse repetition time of 1/1,200 second, or 833 microseconds. This indicates that as far as the PRF is concerned, the maximum range of the radar is the distance a pulse can travel to a target and back in 833 microseconds. To be useful, radar range expressed in time must be converted to radar range expressed in distance (usually miles). Since radio energy travels at a constant velocity of 162,000 nautical miles per second (186,000 statute miles) a transmitted pulse will travel one nautical mile in 6.18 microseconds. Remember that the pulse, to indicate a target at one mile away, must travel a mile to the target and a mile back to the receiver. The pulse travels a radar-mile; that is, a go-and-return mile, which requires 12.36 microseconds.

As a general rule, the pulse repetition frequency (PRF) determines the maximum range of a radar equipment. The radar equipment installed in the F-8E, F-8H and F-8J have a pulse repetition frequency of 1,200 pulses per second, a pulse repetition time of 833 microseconds and a maximum range due to PRF of 67.5 nautical miles (although the highest range scale has been limited to 60 nautical miles on the pilot's indicator for simplicity).

If, for some reason, the pulse of energy should travel farther than 67.5 miles and be reflected, it would return to the radar after the next pulse had been sent out. This is quite common, especially when the divergent beam of radio-frequency energy ultimately hits the ground. This phenomenon is known as second time around echoes (STAE) and does record on the indicator display.

Pulse Detection

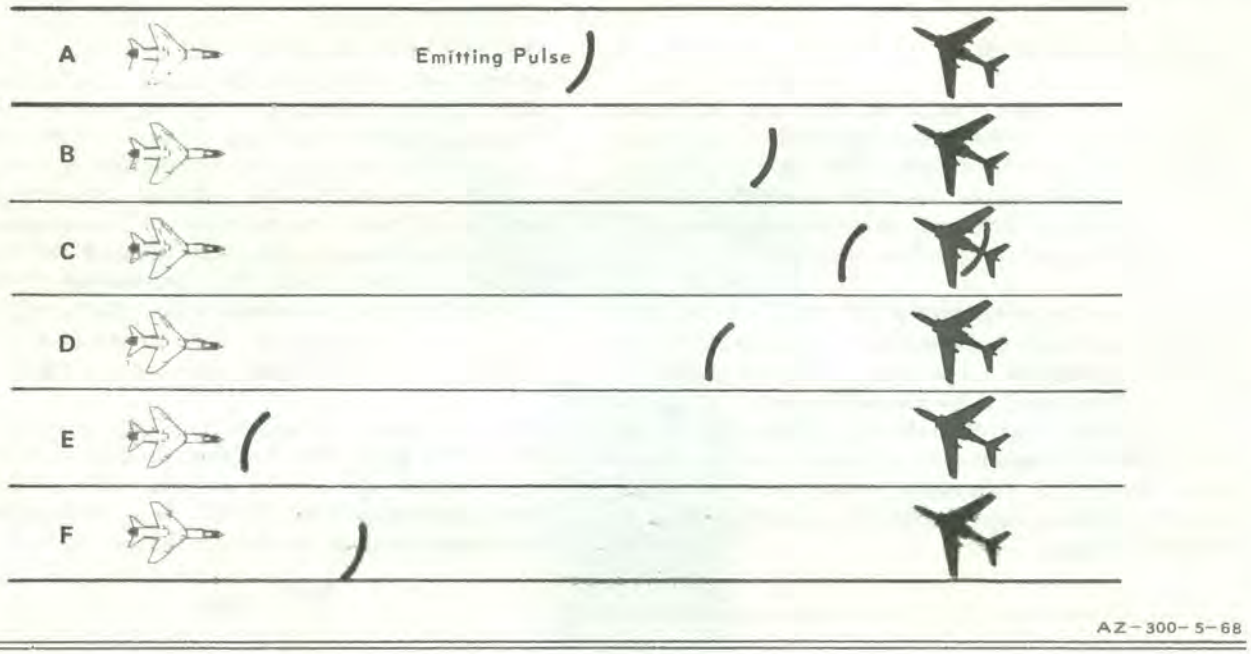


Figure 1–29

Power Output

Although the PRF does determine maximum range, it can be seen that range also depends largely upon the power output of the set. It must radiate enough power so that the received echo signal at the maximum range will have a power level at least equal to the electronic noise in the receiver.

Radar systems have been developed to the degree where they transmit the largest peak power ever radiated by any type radio transmitting equipment. This peak power is sometimes in excess of ten megawatts and seldom less than twenty kilowatts (the F-8 peak power is in the 160 to 180 kilowatt range).

The problem of generating and amplifying reasonable amounts of radio energy at extremely high frequencies and very high power levels are complicated by the physical construction of the electron tubes to be used. Tubes of special design must be used. Among these are such types as the magnetron, klystron, and traveling-wave tubes. In general, these tubes have low interelectrode capacitances, low transit time, and the ability to handle very high levels of RF power.

TRANSMISSION METHODS

There are three major transmission methods which use the basic principles as previously described. They are the frequency shift system (continuous-wave), the frequency-modulation system, and the pulse-modulation system. There is a fourth system which is actually variation of the above known as pulse-doppler, which will be used in the F-8J, F-4J and subsequent fighter aircraft. Pulse-modulation radar ranging will be discussed in this section because it is the most widely used in aircraft today and will probably be retained in the future as one mode of operation even though the emphasis is towards the coherent doppler systems. The F-8J aircraft has both pulse-modulation and pulse-doppler modes. Brief paragraphs on the other types of radar transmission methods will follow the more expanded discussion of pulse-modulation techniques.

PULSE-MODULATION RADAR

Radio-frequency energy, as previously described, can be transmitted in very short bursts called pulses. The pulses are of extremely short time duration, usually on the order of 0.1 to about 50 microseconds (the F-8 radars have a pulse-width of 0.7 microseconds). In this method the transmitter is turned on for a very short time and the pulse of radio-frequency energy is emitted as shown in (A) of figure 1–29. The transmitter is then turned off, and the pulse travels outward from the transmitter at the velocity of light (B). When the pulse strikes an object (C), it is reflected and begins to travel back toward the radar, still moving at the same velocity (D). The pulse is received by the radar (E) and the time interval between transmission and reception is converted to a visual indication of a target at the specific range. The radar cycle then starts over again by transmitting another pulse (F).

FUNCTIONAL COMPONENTS

The functional components of a pulse-modulated radar break down into six essential subsystems. See figure 1–30. These subsystems are:

a. THE SYNCHRONIZER (also known as the timer) supplies the synchronizing signals that time the transmitted pulses, the indicator, and coordinate other associated circuits.

b. THE TRANSMITTER generates the RF energy in the form of short, powerful pulses.

c. THE ANTENNA SYSTEM takes the RF energy from the transmitter, radiates it in a highly directional beam, receives any returning echoes, and passes these to the receiver.

d. THE RECEIVER amplifies the weak RF pulses returned from the target and reproduces them as video pulses to be applied to the indicator.

e. THE INDICATOR produces a visual indication of the echo pulses in a manner that furnishes the required information.

f. THE POWER SUPPLY provides the electrical power requirements of all the components in the radar.

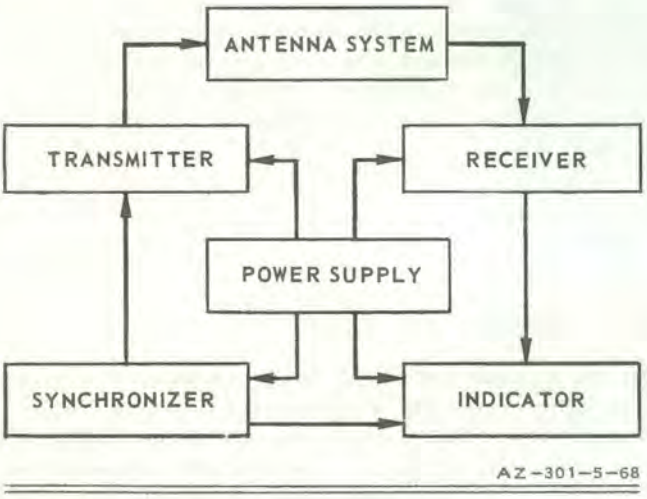


Figure 1-30. Fundamental Radar System Functional Block Diagram

While the physical configurations of radar may differ, any radar system may be represented by a functional block diagram. An actual radar set may have several functional components within one physical component, or any one of these functions may require several physical components. However, the functional block diagram of a fundamental radar set may be used to analyze the operation of almost any radar set. In the following paragraphs, a brief description of each of the major essential components is given.

Synchronizer

The synchronizer ensures that all circuits connected with the radar system operate in a definite time relationship. It also times the interval between transmitted pulses to ensure that the interval is of the proper length.

The pulse repetition frequency can be determined by any stable oscillator such as the sine wave oscillator, a multivibrator, or a blocking oscillator. The output is then applied to necessary pulse shaping circuits to produce the required timing pulse. Associated components can be timed by the output of the synchronizer or by a timing signal from the transmitter as it is turned on.

Transmitter and Modulator

The transmitter's main component is an RF oscillator using a tube of special design (such as a magnetron) which generates powerful pulses of RF energy at regular intervals. Since the resting time is very long compared to the transmitting time, the oscillator may be greatly overloaded during transmission time to increase the peak power. The oscillator requires operating power in the form of a properly timed, high amplitude, rectangular pulse. This pulse is supplied to the RF oscillator (magnetron) by a component called the modulator. This modulator supplies its high voltage pulse to either the plate or cathode of the RF oscillator, depending on what type of tube is used for the oscillator. Normally, because of the very high voltage involved, the pulse is supplied to the cathode and the plate is grounded to shield personnel from shock hazards. The modulator switches the oscillator on and off. The modulator pulse applied to the oscillator may be more than 100,000 volts in some of the large early warning radars, or only a few hundred volts in some of the small airborne radars.

Antenna System

The antenna system takes the energy from the transmitter, radiates it in a directional beam, picks up the returning echo, and passes it to the receiver with a minimum of losses. The antenna system includes the transmission lines and waveguide from the transmitter to the antenna, the antenna itself, the transmission line and waveguide from the antenna to the receiver, and any antenna-switching devices and receiver-protective devices that may be present.

Most radars now use parabolic-reflector (dish-shaped) type antenna systems. This type antenna is a practical means of producing a narrow beam pattern of microwave radiation. The reflection of RF energy by the paraboloid is closely analogous to the reflection of light by a parabolic mirror. A flashlight is an example of this effect. Many variations of the basic parabolic

shape are used to obtain acceptable beam patterns for radars with different tactical uses.

When a radar receiver is operated close to a powerful radar transmitter, a certain amount of the transmitted signal inevitably finds its way into the receiver. This phenomenon is commonly known as the main bang. In certain instances, such signals resulting from the main transmitted pulse must be entirely eliminated from the output of the receiver. Therefore, the receiver must be turned off, or gated, during the pulse time so that it will be completely insensitive. On the other hand, some radars are designed to permit a very small amount of the transmitter pulse to be coupled to the receiver for timing. Both of these conditions place a limit on the amount of transmitted pulse that can be permitted to reach the receiver; keeping the amount of "coupled" pulse to the permissible levels is the job of receiver-protective devices.

Usually a radar antenna system has a single antenna and an antenna switch capable of connecting the antenna to the transmitter during the transmission time and to the receiver during the remainder of the pulse period. The switch is necessary to protect the receiver from the transmitter during the pulse time and to isolate the transmitter during the receiving time. Otherwise the weak echo signals might be wholly or partially lost in following the transmission line or waveguide back to the transmitter. The transmitted pulse width and the pulse repetition frequency of the radar eliminate the use of a mechanical switch. The electronic device used to perform this switching is usually called a duplexer. Another common name is the TR (transmit-receive) tube.

Receiver

The receiver takes the weak echo signals from the antenna system, amplifies them sufficiently, detects the pulse envelope, amplifies the pulses, and feeds them to the indicator. Since radar frequencies are very high, they are very difficult to amplify. Therefore, one of the main functions of the radar receiver is to convert the frequency of the received echo signal to a lower frequency that is easier to amplify. This lower frequency is called the intermediate frequency (I-F). The type of receiver that makes use of this frequency conversion is called a superheterodyne. Common AM and FM radios are also of the superheterodyne type. Superheterodyne receivers used in radars must have good stability and extreme sensitivity. The stability of operation is ensured by careful design and the overall sensitivity is greatly increased by the use of many I-F stages.

Indicator

The indicator uses the received signals obtained from the radar receiver to produce a visual indication of the desired information. The cathode-ray oscilloscope is an ideal instrument for the presentation of radar data, since it not only shows a variation of a single quantity such as voltage but gives an indication of the relative values of two or more synchronized variations. The usual radar indicator is basically a rectangular tube in which range is displayed vertically and azimuth horizontally. The range sweep starts at the bottom of the indicator (representing the instant the receiving cycle starts) and is traced vertically outward to the limit of the receiver time or the range scale selected. A target is represented by an intensity modulated "blip" at the correct location on the timing line. It remains then that the indicator must be appropriately marked to enable the pilot to determine the range. The sweep of the range timing line is so rapid to the eye that it appears as a solid vertical line that sweeps back and forth in azimuth, leaving target "blips" at the range and bearing that they occur. Such an indicator is known as a B-scope and is almost universal in air-intercept (AI) radars. The timing-line is known as the B-trace. There are other scope presentations such as the A (range-only displayed horizontally from left to right) and the PPI scope (a 360-degree circular display about the location of the antenna) with range increasing radially outward. The A-scope has certain surface fire control and laboratory applications while the PPI is used for long range air and surface search installations.

Power Supply

In the general functional block diagram of a radar set, the power supply is represented by a single block. Functionally, this block is representative; however, one power supply may not meet all the requirements of a radar set. The distribution of the physical components of the system may be such as to make it impossible to place all the power supply circuits into one physical unit. Thus, different supplies may be needed to meet the various requirements of the set and must be designed accordingly. Essentially the power supply converts the low voltage power from the aircraft's electrical system to voltages and currents suitable for the electronic circuits of the complete radar set.

SUMMARY OF BASIC PULSE-MODULATED RADAR SYSTEM

Now, after having become familiar with the description and function of the major components of a radar set, it is possible to see how these components operate together to detect and determine the location of a target. The radar cycle of operation starts with the synchronizer. The synchronizer generates two simultaneous timing signals known as "triggers" that are sent to the transmitter and the indicator. When the transmitter is triggered, it generates a powerful RF pulse that is sent to the antenna, where it is emitted toward a target.

At the same time, the second timing signal triggers the sweep generator in the indicator, and the sweep begins to move up the face of the cathode-ray tube. Thus, the sweep starts up the indicator screen at exactly the same time the transmitter pulse starts out into space. The pulse travels toward the target in space and the sweep continues up the screen of the indicator.

When the pulse strikes the target, nothing happens on the indicator (because the pulse must return to the receiver to be detected). When the reflected pulse does reach the antenna, it is fed to the receiver and in turn to the indicator where it is recorded as a target "blip." The distance up the vertical trace on the indicator that the "blip" occurs is representative of the target's range. The azimuth is easy to determine since the antenna, moving back and forth, is electronically coupled to the vertical B-trace. This causes the B-trace to sweep back and forth horizontally in coincidence with the mechanical position of the antenna. Elevation is actually the easiest to understand since it would be impossible to detect a target if the antenna were not pointing its beam at the target's correct elevation. As mentioned, the B-scope is a rectangular tube with range measured vertically and azimuth indicated horizontally. By locating our range scale on the left-hand side of the indicator we can very easily devise an elevation scale and locate it on the right-hand side of the indicator. The target "blip" cannot be compared to this elevation scale but an electronic marker can be produced along the right-hand scale to indicate the position of the antenna in elevation with respect to the aircraft's nose. With a little stabilization added to the antenna it can easily be seen that the antenna position and the elevation (tilt) marker on the indicator can be referenced to the horizon. Now the pilot knows where his antenna is positioned vertically and the existence of a target "blip" on the scope gives him range and relative bearing, thus completing the three-dimensional indication of the target.

ADDITIONAL CIRCUITRY FOR AI RADARS

In order to really give our basic radar an intercept capability we must be able to track (lock-on) a target. This provides a continuous readout of target information to the various missile and gun fire control computers and the resultant proper solutions to accurately fire the weapons.

Range Tracking

The basis of range tracking is relatively simple. First, the video signal that represents the target is made bipolar (a single sine wave having the first half negative and the second half positive). In terms of time (which in radar is distance), a single sine wave would exist at the exact distance from the beginning of the timing as the target that is being displayed on the indicator. If a synthetic gate (as wide as our pulse width) is made that we can electrically position by means of a hand control, we have a means of selecting the target that we wish to lock-up. The pilot merely superimposes this synthetic gate over the "blip" on the scope with the hand control. This is electrically placing the gate in coincidence with the single sine wave representing the target's range. The circuitry is such that whenever the gate comes in contact with a negative signal it is caused to move outward in range. Whenever it comes in contact with a positive signal it is caused to move inward in range. Since the first half of the single sine wave representing the target is negative, when the synthetic gate is superimposed over the sine wave manually its first reaction is to move outward but it immediately comes in contact with the positive half of the sine wave and moves back inward. The gate actually finds equilibrium and settles down over the target. The gate moves in range as the target moves in range effecting range tracking as long as a target signal exists.

Angle Tracking

Angle tracking is accomplished by spinning the antenna slightly off-center (eccentric spin). This spin is known as nutation. Whenever the antenna is pointing at a target, the return energy measured at the receiver is sinusoidal because there is only one position during the antenna's spin where it is pointing most at the target and only one position (180 degrees away) where it is pointing least at the target. If the antenna is made to spin at a precise rate and is made to create a reference voltage (spike) every 360 degrees, it is readily seen that by comparing the peak of the sine wave with the spike reference voltage we have

the angular position or angle from the reference position that the antenna receives the most return. By building a hydraulic servo system to drive the antenna it can be mechanized to drive toward the target's maximum return. When the antenna is aimed exactly at the target there is no sine waveform and therefore there would be no signals to cause the antenna to move. We have angle tracking by means of creating an aiming error to determine in which direction the target is and move our antenna in that direction until there is no error signal. Appropriate symbols are synthetically created to display the position the antenna is assuming on the indicator.

Fire Control Data and Artificial Horizon

To complete the AI radar, synthetic symbols are manufactured to display maximum and minimum missile firing ranges. This data comes from the Fire Control computers. The artificial horizon is also displayed on the indicator and it is driven by the same gyro as the VGI instrument.

OTHER TRANSMISSION METHODS

Continuous-Wave Method

The continuous-wave method operates on the principle of the Doppler effect. The Doppler effect is the apparent change of frequency of light, sound, or electromagnetic radiation that is observed when the radiating source and the observer are in relative motion. This frequency shift is external to the transmitter; that is, the transmitter operates at a fixed frequency. A common example of the Doppler effect is the changing pitch of the whistle of an approaching train. The train's whistle appears to change in pitch from a high tone as the train approaches to a low tone as it moves away from the observer. As the train approaches there is an apparent rise in the frequency, as the train moves away there is an apparent lowering in frequency.

In radar, the set differentiates between the transmitted and received waves, and thus determines the speed of the moving object. The Doppler method is the best means of detecting the presence of fast-moving targets that do not require range resolution. The amount of frequency shift is very small when compared to the carrier frequency; however, a shift of one quarter cycle at 10,000 megacycles will give a speed measurement to a fraction of a percent. A disadvantage of the system is that it does not determine the range to the target, nor is it able to differentiate between targets when they lie in the same direction. Moreover, it does not "see" stationary or slow-moving objects which a pulse radar system can detect.

Frequency-Modulated (FM) Method

In the frequency-modulated method, the transmitter radiates radio-frequency waves whose frequency is continually increasing and decreasing from a fixed reference frequency. At any instant, the frequency of the returned signal differs from the frequency of the radiated signal by an amount which is determined by the time it took the signal to travel the distance from the transmitter to the target.

This system works well when the object is stationary. It is used in aircraft altimeters which give a continuous reading of the aircraft's true height above the ground. This system is not satisfactory for the location of moving targets, however, because moving targets produce a frequency shift in the returned signal because of the Doppler effect; this affects the accuracy of the range measurement.

DETECTION SYSTEMS

GENERAL

The AN/APQ-83B and the AN/APQ-124 radar sets are designed to provide the F-8 pilot with a means of non-visual detection of airborne targets within 45 degrees of the radar boresight line. After target detection, the radar will then provide the pilot with a means of making an effective non-visual approach to where an attack can be launched on the target. During the attack phase, the radar provides the pilot with the information required for effective non-visual aiming and release of Sidewinder series missiles. Range and range rate information are provided to the external optical fire control system to enable a visual gun attack on the target.

The APQ-83B radar has a 12 to 15 mile range of probable detection, and the APQ-124 has a 16 to 18 mile range of probable detection against a fighter-type target at medium altitudes, with the fighter co-altitude or slightly lower than the target. Against extremely high altitude targets, performance may degrade and depends upon pilot operating experience and antenna tilt control. At extremely low altitudes, radar performance can be as good as at higher altitudes. However, sea state, STAE (second-time-around echoes), and atmospheric ducting can degrade performance. As with any AI (airborne intercept) radar, search performance is increased when an up antenna tilt can be used. Low altitude performance over land is very poor because of STAE and ground clutter effects. The radar is very susceptible to all types of ECM, its only design counter-countermeasure being an ability to automatically angle-track a spot noise jammer.

Weather, especially in the form of heavy clouds and rain, will degrade performance. Flying close to a stratus layer may also degrade performance due to STAE.

The practical antenna look-up limit for both the APQ-83B and the APQ-124 radars is about 25,000 feet with good target altitude information and expert antenna tilt control. It is difficult to define a practical lookdown limit because it is affected by STAE, sea return and land clutter. These may vary greatly, depending on sea state and the proximity of land masses and cloud layers. During low-level-intercept radar performance is degraded when the target altitude is below the fighter.

Raid altitude information is very important to detection probability because the F-8 pilot must fly the aircraft and operate the radar. Since the radar look-up capability is much better than the look-down capability, efforts should be made to position the fighter below the target. The APQ-124, having a pulse Doppler function, provides a look-down capability superior to previous F-8 radar systems.

INDICATOR DISPLAYS

Radar Search B-Picture

The radar search B-picture displays antenna azimuth, range timing and target information.

Range timing is accomplished by drawing a vertical line on the indicator starting at the bottom each time the transmitter pulses. The electron beam which draws this line is moved from the bottom of the indicator to the top in a linear manner in the exact amount of time it takes for the transmitted RF pulse to reach and return from a target at the range selected.

Target returns from the radar receiver cause the timing line to brighten so that a radar echo from 20 miles would cause a bright spot at the top, one from 10 miles would cause it to brighten in the center (APQ-83B), etc. Thus the range of a target return can be determined by noting its vertical position on the timing line.

To present azimuth information, the timing line is caused to move in coincidence with the antenna azimuth motion so that if the antenna is dead ahead, the timing line is centered; if the antenna is 45 degrees to the right, the timing line would be one inch to the right of center; etc. Thus target azimuth can be estimated by noting the target's azimuth position on the indicator.

B-Picture Azimuth Distortion

The B-type display has inherent distortion which should be kept in mind. The actual area in view of the radar antenna is a pie-shaped sector, yet it is represented on the radar indicator as a rectangle.

A target caused to move down the B-picture along the collapsed B-trace shown in Detail B, figure 1–31, would result in a collision since it represents a target moving along the dotted line in Detail A, figure 1–31. This fact can be used effectively in making a collision approach to the target by flying to eliminate azimuth motion of the target on the indicator. The pilot should keep in mind that his own aircraft is spread out along the entire bottom of the B-display.

APQ-83B RADAR PERFORMANCE

Overall performance of the APQ-83B radar is excellent within its design limits. Given a properly adjusted radar, detection and lock-on ranges are adequate for a high probability of successful interception of the complete range of probable threats. Graphs showing the cumulative probability of detection and lock-on for an F-8 target (approximately a 2 square-meter target) are presented in figures 1–32 through 1–35. Data for the graphs were collected during the operational evaluation of the F-8D. As seen from the graphs, the 80 percent probability of detection at mid-altitude is approximately 15 miles and is independent of target aspect except for the forward quarter. The reduced detection ranges on the forward quarter are the result of the reduced effective radar reflective target area in this region. The curves showing lock-on ranges do not signify radar capabilities but are based on actual intercept results. The radar can lock on at a greater range, but pilot reaction time, intercept analysis, and target confirmation with CIC delays actual lock-on beyond the time of initial detection.

B Picture Azimuth Distortion

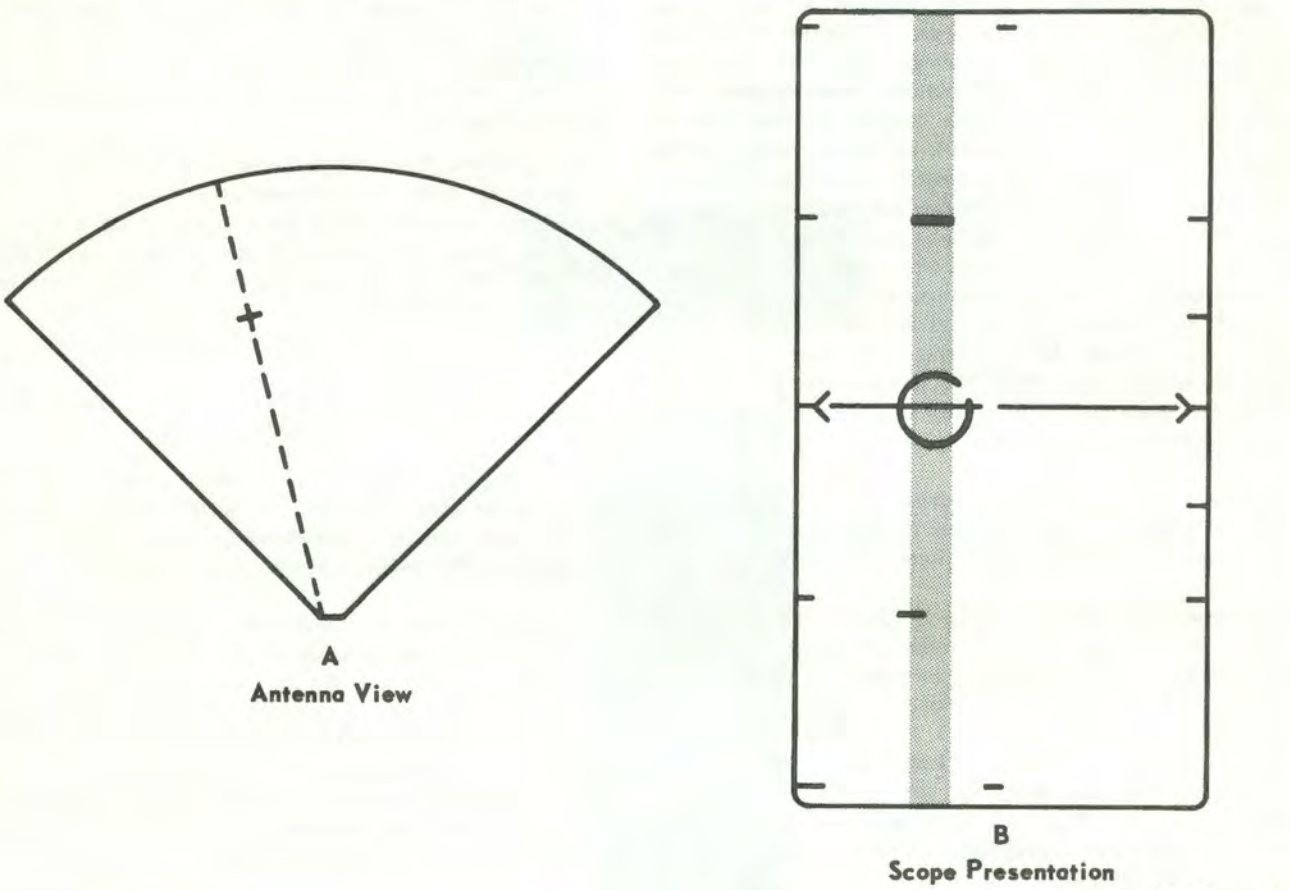
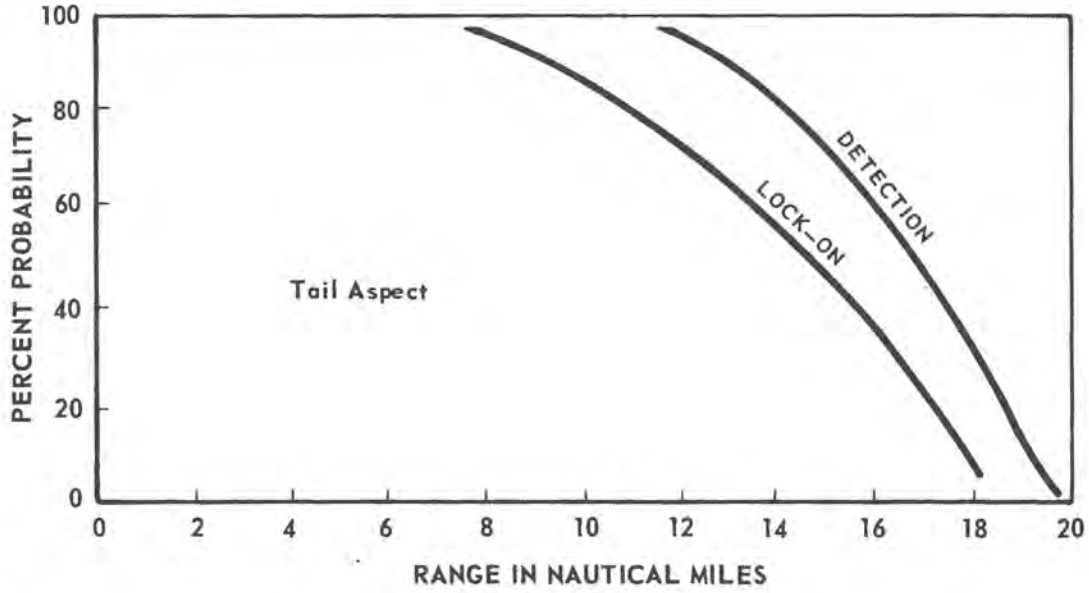


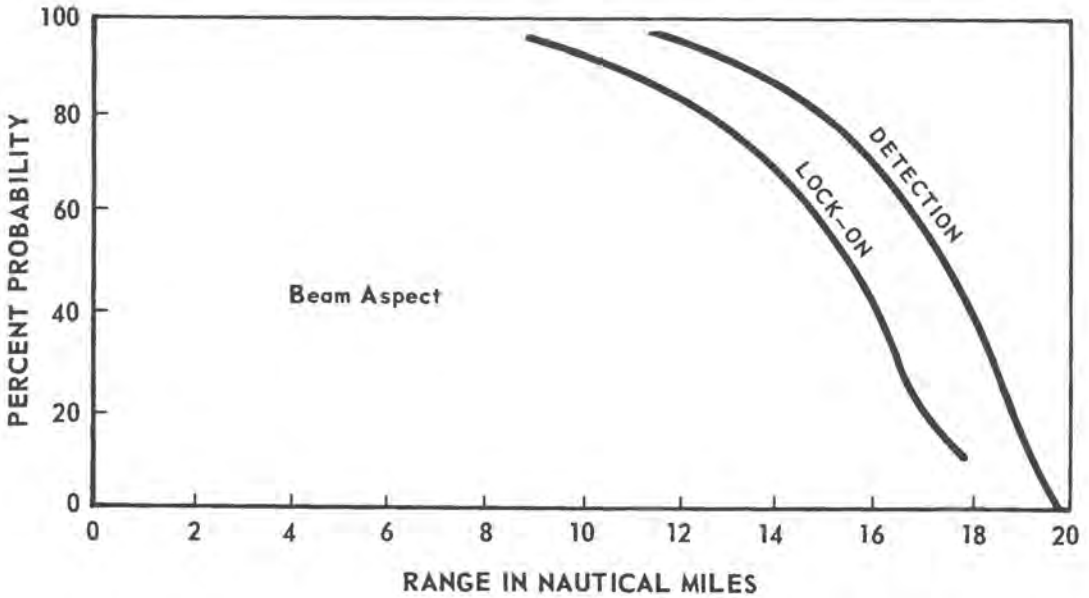
Figure 1–31

APQ-83B Cumulative Probabilities of Detection and Lock-On

TAIL ASPECT – BEAM ASPECT



Target: F–8
Altitude: 25M to 45M

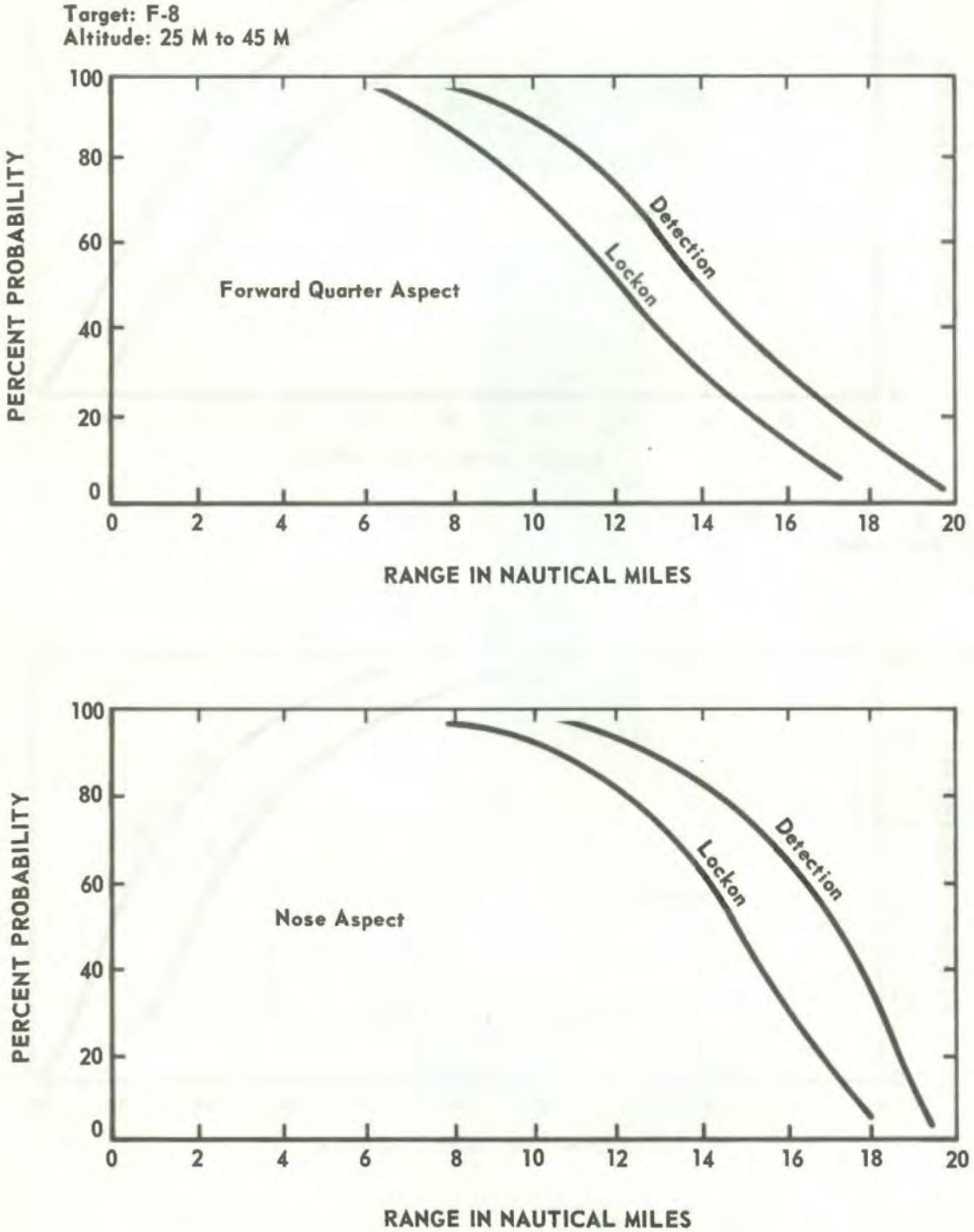


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Figure 1–32

APQ-83B Cumulative Probabilities of Detection and Lock-On

FORWARD QUARTER ASPECT – NOSE ASPECT



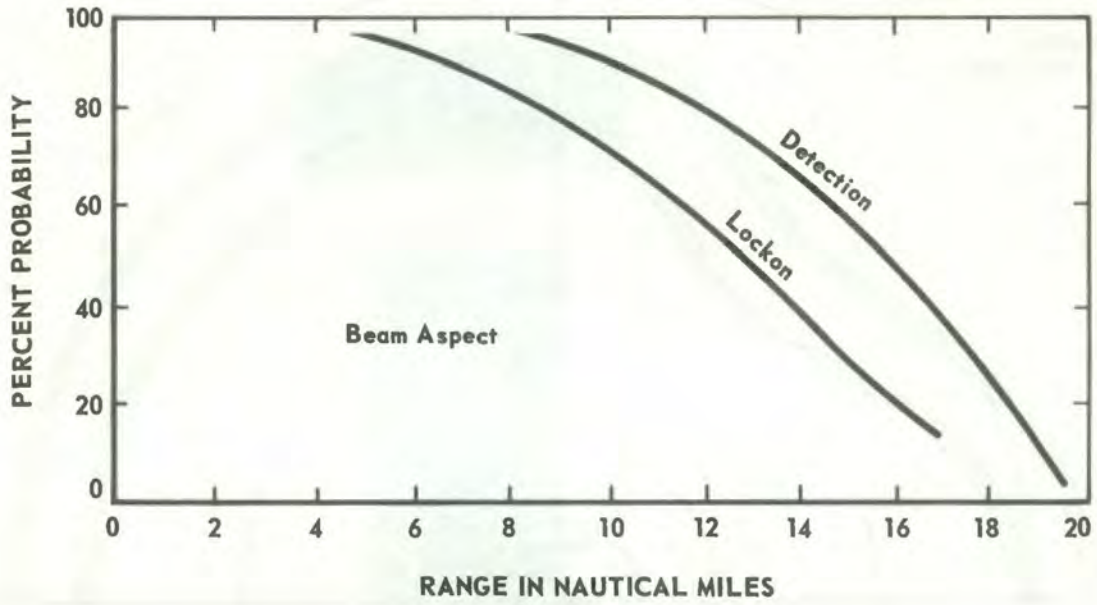
AZ-24-5-68

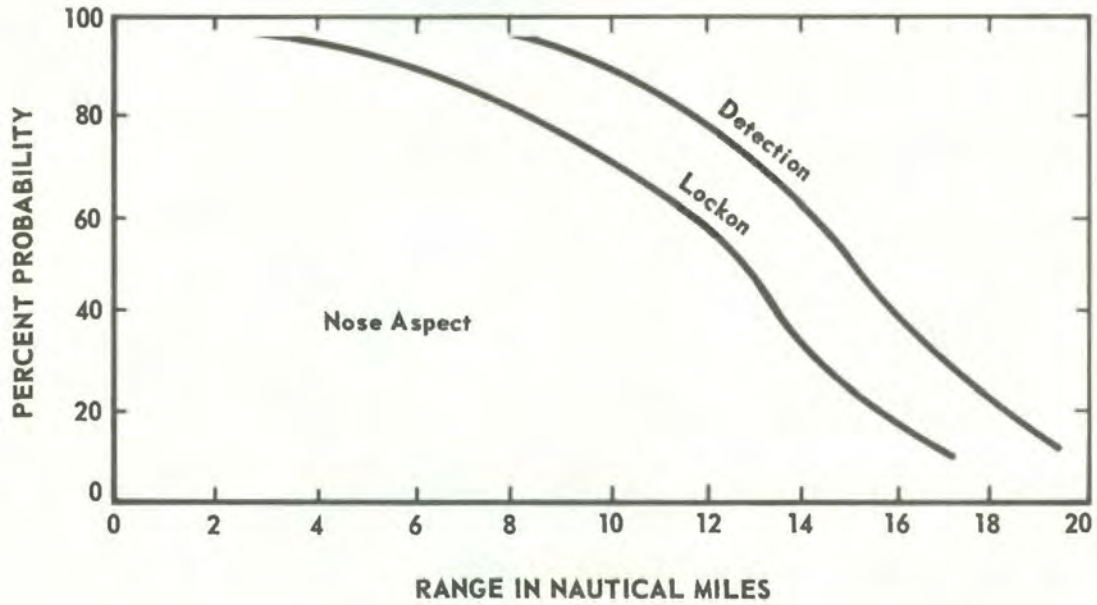
Figure 1–33

APQ-83B Cumulative Probability of Detection and Lock-On

BEAM ASPECT – NOSE ASPECT

Target: Fighter Aircraft
Altitude: 100 Ft to 1000 Ft





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Figure 1–34

APQ-83B Radar Detection Envelope

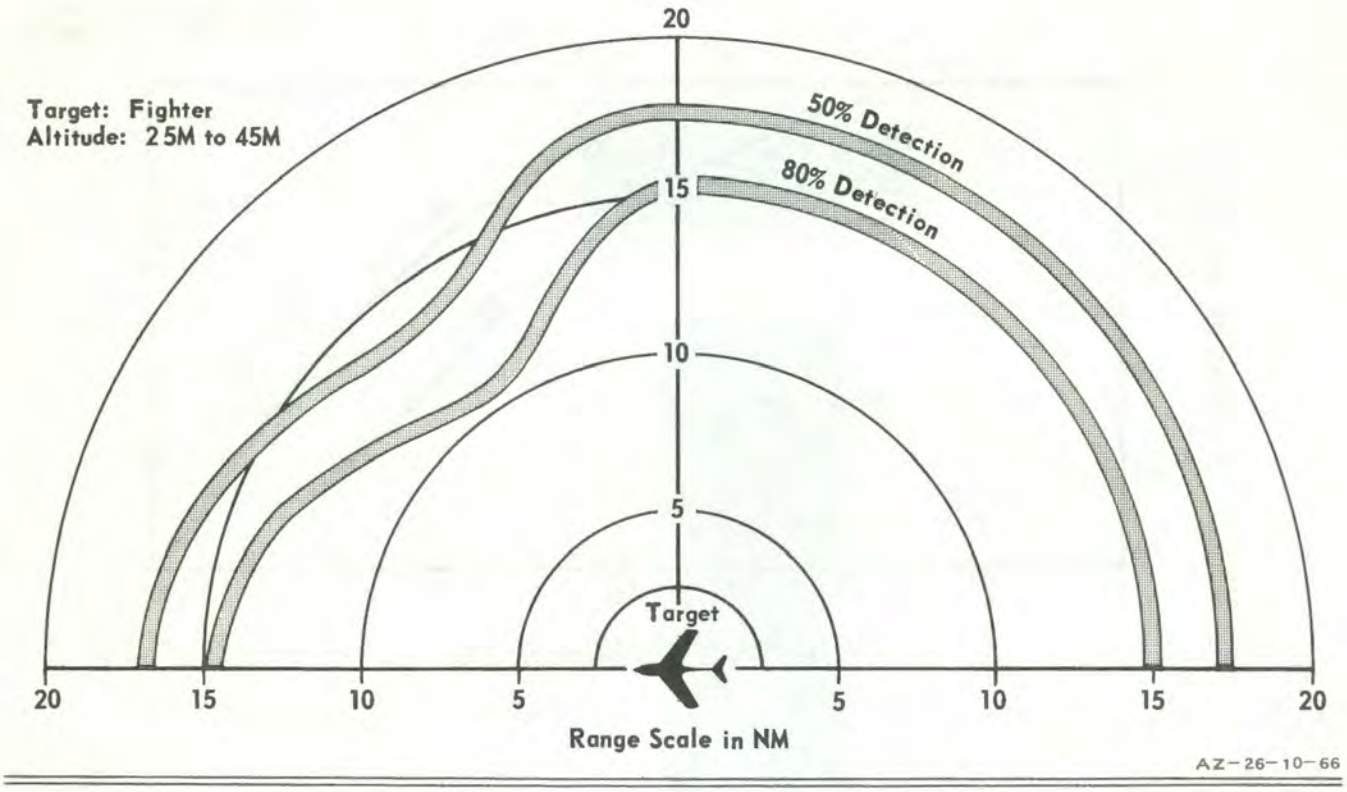


Figure 1–35

APQ-124 RADAR PERFORMANCE

The detection capability of the APQ-124 radar should be approximately 30 percent better than the APQ-83B. Graphs showing probability of detection are presented in figures 1–36 and 1–38. Cumulative probability of obtaining and maintaining lock-on is presented in figure 1–37. Data for the graphs were collected during the operational evaluation of the F-8H (APQ-83B) and are projections of APQ-124 performance. Actual APQ-124 graphs will be presented when the operational evaluation of the F-8J system is completed. As indicated by the graphs, detection of a small radar target is exceedingly difficult in the pulse modulation mode unless the fighter can be positioned sufficiently below the target to allow at least three-degree look-up. Excessive scope clutter may be found at ranges beyond 20 miles with look-up angles less than three degrees. The clutter will normally be heavy when operating over water, depending on sea state and direction, and significantly worse when operating over land, depending on terrain. The clutter is caused by main and side lobe energy returns from the ground or by STAE from the main lobe.

APQ-83B/-124 GROUND CHECKS

Before starting the aircraft, check all the radar control box switches and scope controls. On the control box, ensure the radar is OFF, FTC is normal and the mode selector is in IR. On the scope, place the range scale selector at the extended range and the extended range lamp will immediately illuminate when the radar is turned on, indicating power to the scope.

After starting the aircraft, ensure that the cockpit pressurization is ON. Select any radar operating position on the control box, figure 1–39. After illumination of the scope (four to six minutes) in IR, focus the display to the sharpest possible image. At this time, check the narrow antenna scan patterns. Do not attempt to operate in a radar mode unless the aircraft is pointed so that the area within the gimbal limits to a distance of 150 feet is clear of all personnel, fuel trucks, etc. It is generally not permitted to operate the radar from a CVA flight deck without the anti-radiation cover. If it is safe to ground check the radar modes, depress the test targets button in the lowest range scale and readjust the B-FOCUS to obtain sharp, clear test targets. Adjust GAIN, B-CONTRAST and B-BIAS to obtain maximum target-background contrast. Holding the test targets button down, check the lock-on performance of the radar (APQ-124 in PULSE). Determine the reference position (ADL) of the tilt mark in ARO(APQ-124 in BAT). Check the position of the range rate (V_r) gap to determine zero range rate position.

APQ-83B/-124 AIRBORNE CHECKS

Using another aircraft as target, readjust the gain and B contrast controls to the point of maximum target to background contrast level. Recheck the focus controls and check the position and motion of the artificial horizon.

Obtain a lock-on on the target, check track lamp illumination and commence closing. During the initial portion of the run, check the automatic gain feature by noting the varying intensity of the collapsed B-trace. Determine the boresight relationship of the fixed pipper on the gunsight and the steering circle and dot. Also cross-check boresight of missile tones with radar and gunsight information. Deflect the aircraft nose in pitch and yaw and check the steering information. Observe the range rate gap position. When in range, check operation of the in-envelope lamp. Continue the run and observe the breakaway X at R_{min}.

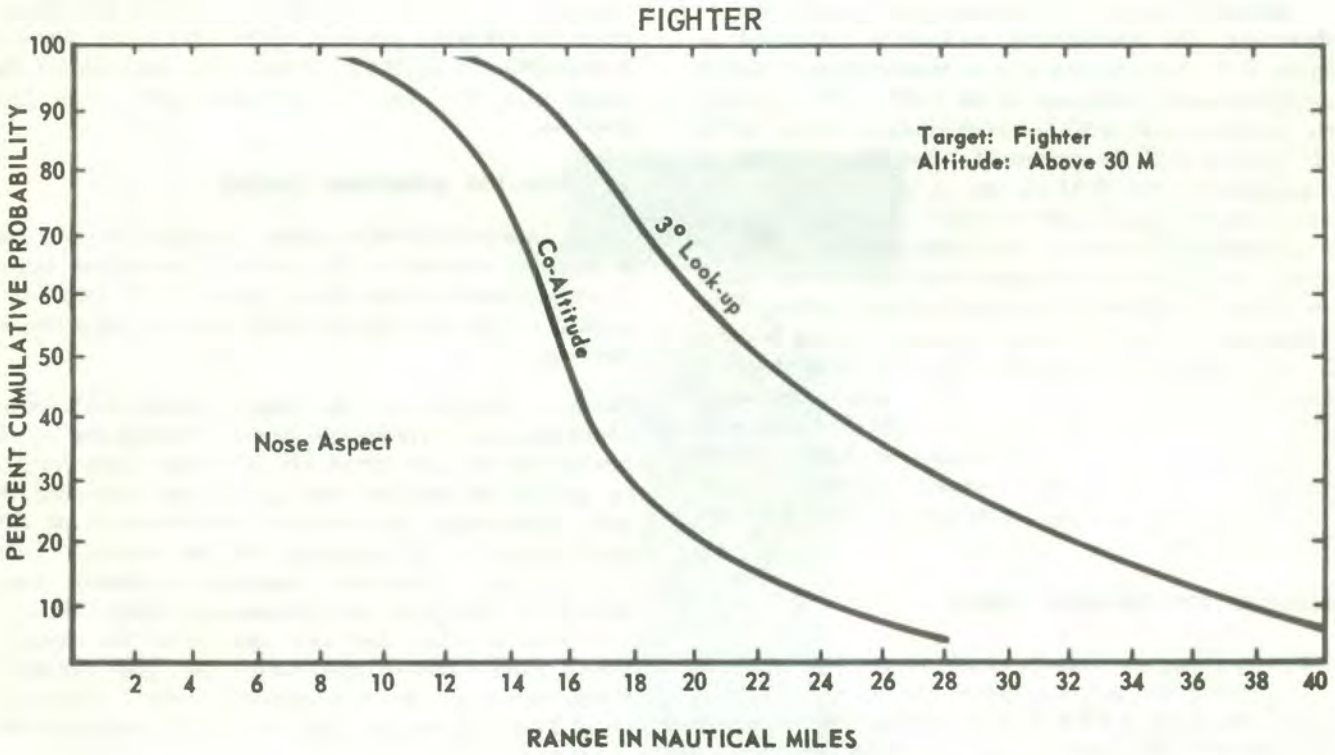
To check the operation of BAT (Boresight Acquisition Track) or GARO (Guns Automatic Ranging Only), reattack from beyond 5,000 feet. Check lock-on by observing illumination of the BAT TRACK lamp. Note the lower needle of the range meter tracking the target in range and the illumination of the missile in-envelope lamp. The in-envelope lamp should extinguish at missile R_{min}. Terminate the run when satisfied all three gun firing tones are functioning.

General Safety Precautions

It is always wise to remember the utility hydraulic system when operating the APQ-83B or APQ-124. Both antenna drive mechanisms use utility hydraulic power.

APQ-124 Probability of Detection

PREDICTED CAPABILITY PULSE MODE



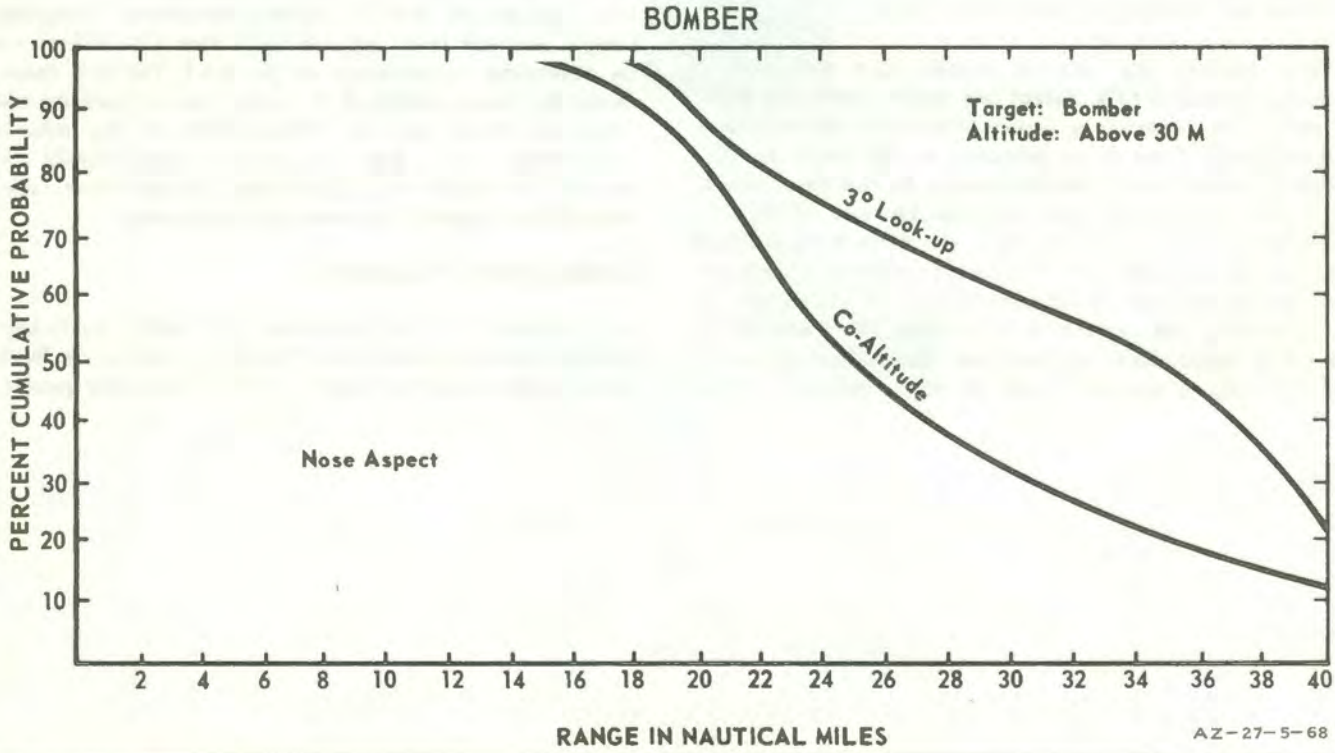


Figure 1–36

APQ-124 Cumulative Probability of Obtaining and Maintaining Lock-On



PREDICTED CAPABILITY PULSE MODE

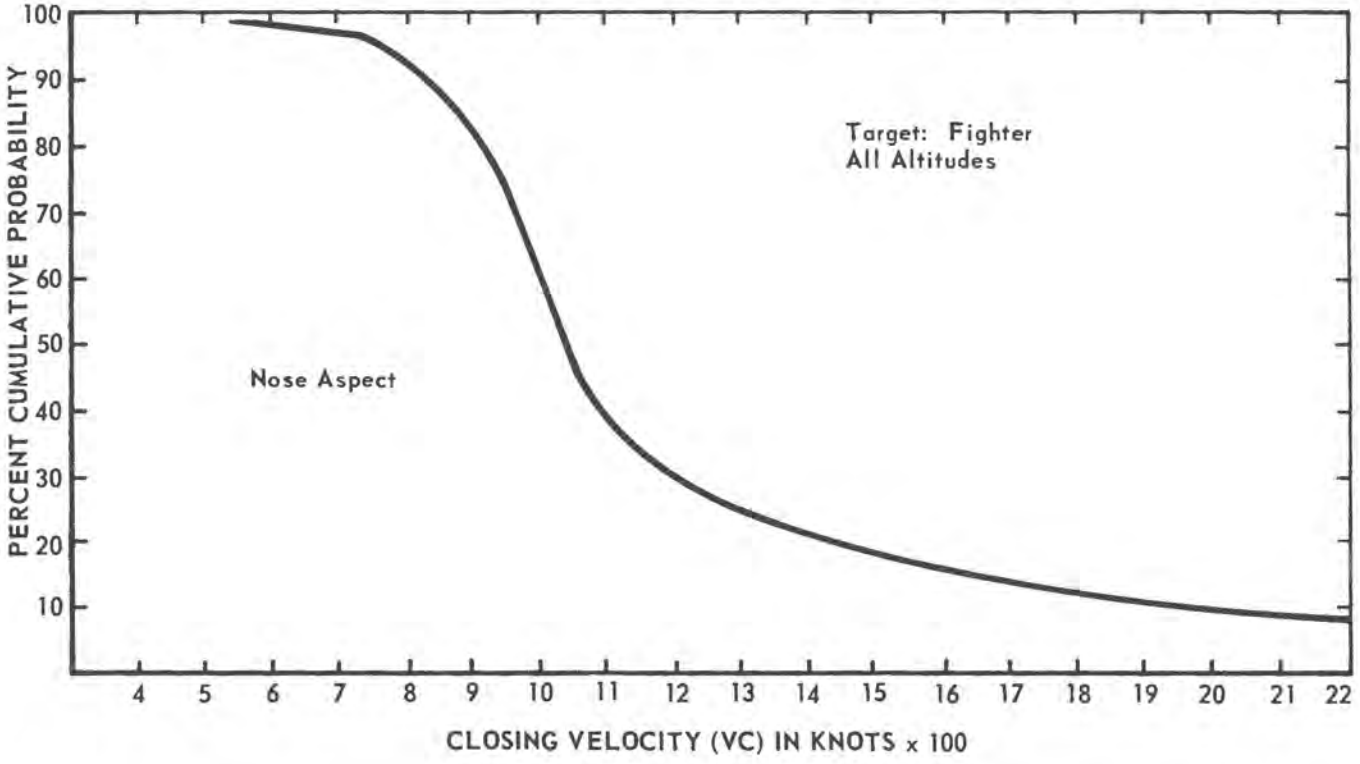


Figure 1–37

APQ-124 Cumulative Probability of Detection



BEAM AND TAIL QUARTER ASPECT —
PREDICTED CAPABILITY PULSE MODE

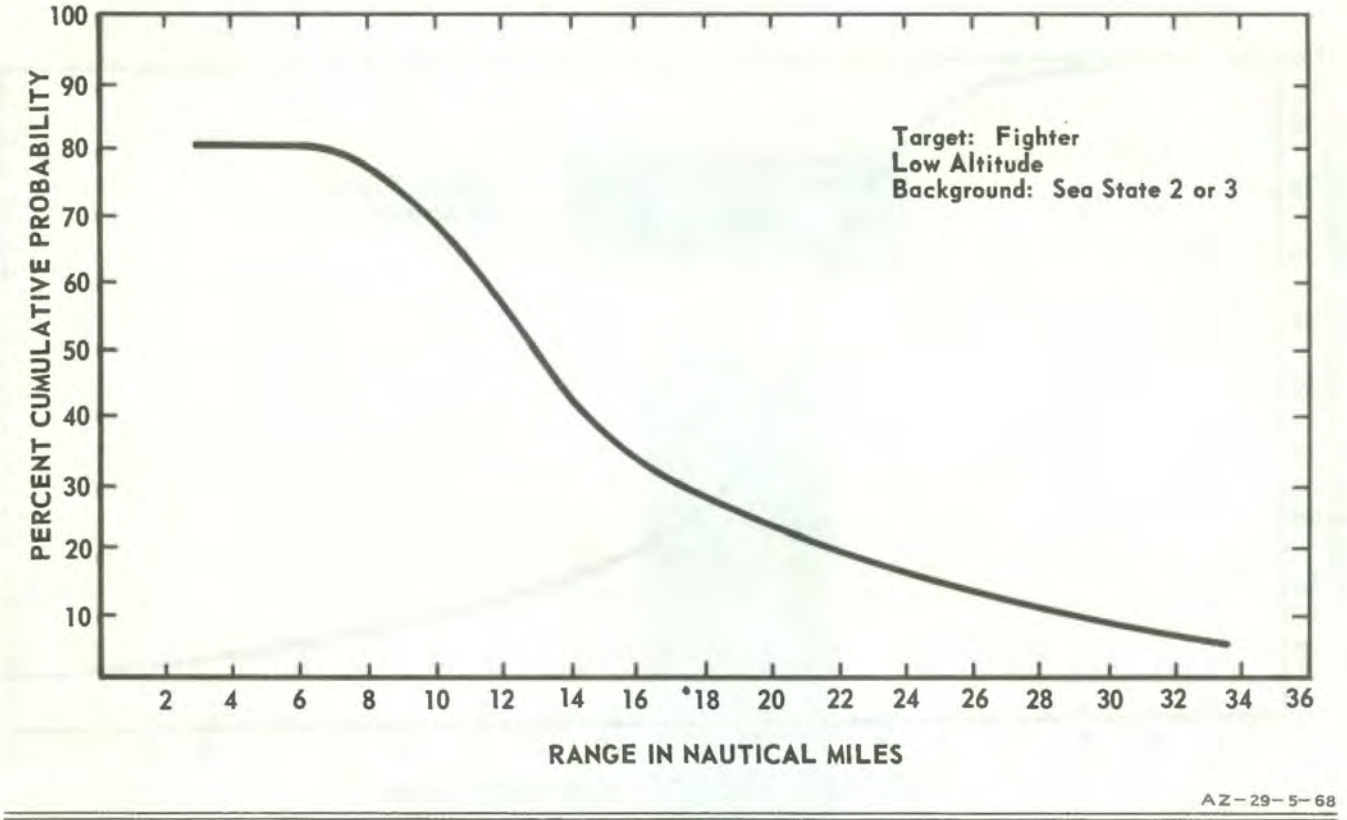
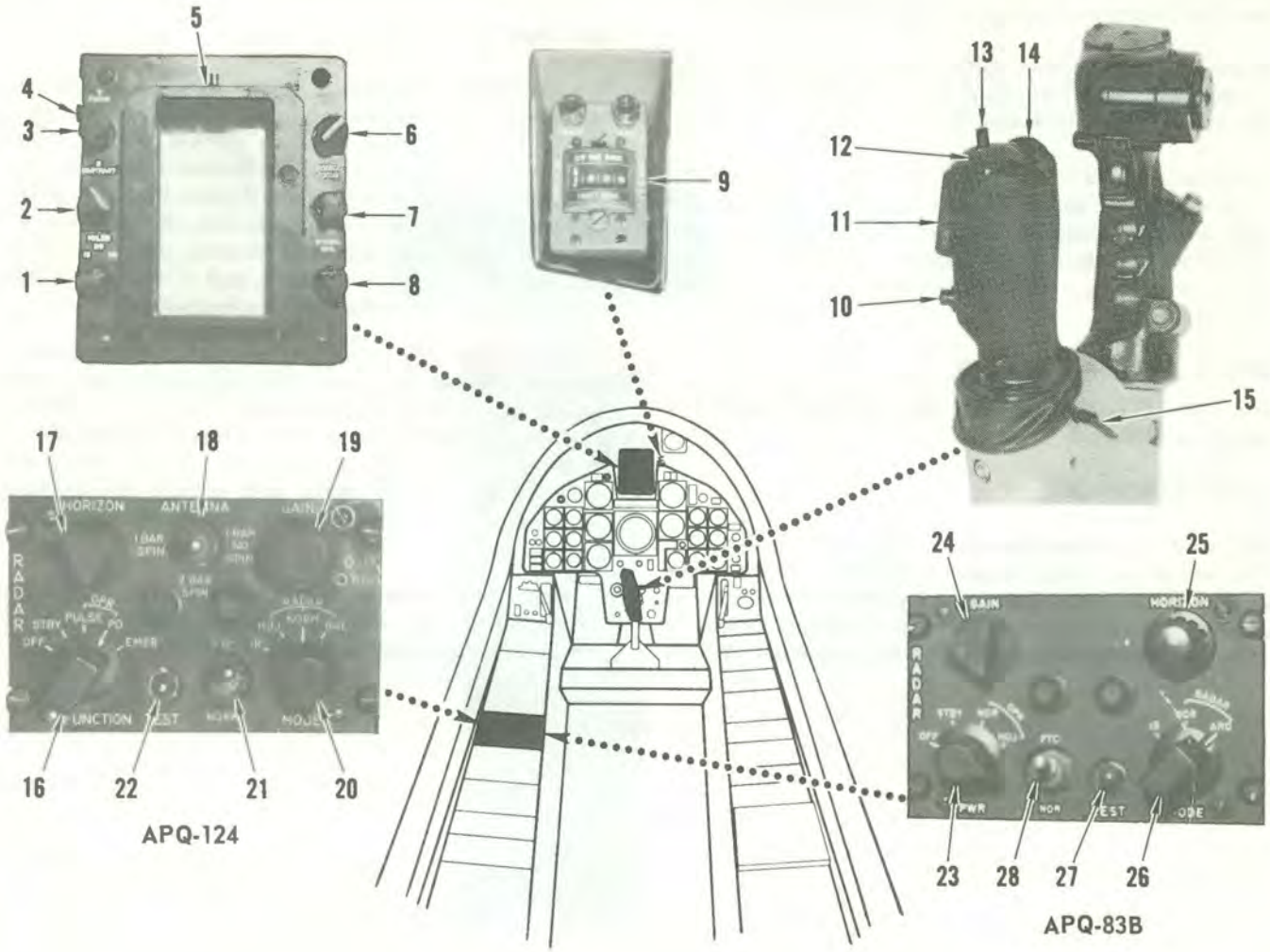


Figure 1–38

Radar Controls



LEGEND

1. Range Selector Switch (APQ-124 scope shown. Different ranges on APQ-83B scope.)
2. B Contrast Control
3. B Focus Control
4. B Bias Control
5. Radar Scope Bezel
6. Bezel Dim Control
7. Symbol Focus Control
8. Symbol Brilliance
9. Sidewinder Firing Indicator
10. Microphone Switch
11. Acquisition Button
12. Sector Scan Switch
13. Seam Scan Lockon Button
14. Antenna Tilt Control
15. Antenna Control Grip Lock
16. Function Switch
17. Horizon Knob
18. Antenna Sweep Control
19. Gain Control
20. Mode Switch
21. FTC Switch
22. Test Target Switch
23. Power Switch
24. Gain Control
25. Horizon Knob
26. Mode Switch
27. Test Target Switch
28. FTC Switch

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Figure 1–39

If a falling utility pressure is noted, secure the radar. The radar antenna can be secured by selecting the track mode in IR. This satisfies the rquirement to keep the radar system at operating temperatures.

Whenever the antenna search pattern becomes erratic or slows down, this could be an early warning of impending utility hydraulic failure.

The radar should be secured if an erratic or fluctuating electrical power supply is noted. Always take off and land with the radar on and in the IR mode. Radar reliability increases if the electronic package is kept up to operating temperatures when the aircraft is moving.

AIM-9C AIRBORNE TUNING

See AIR-TO-AIR MISSILES, Part 6, this section, for tuning procedures.

PILOT TECHNIQUES

The most important factors which the pilot can control to effect early target detection are optimum setting of the gain control and proper use of the tilt control. Next in order of importance is pilot experience in scope interpretation, that is, knowing what to look for. Detection of the target is also facilitated through the use of various features in the radar, such as sector scan, FTC or the Doppler mode.

Gain Setting

The optimum gain setting is one which provides the best target-to-background (noise). Normally, the gain should be set so that a faint "sparkle" return from noise is seen on the scope. The B-trace will be a faint and continuous line when the B-trace intensity is set properly. This condition ensures that the existence of any return from a target will be seen, since it will be stronger than the noise return, and it will stand out well in contrast with the noise background.

If the gain is set too low, an excellent target-to-background contrast will exist, but detection ranges will be degraded. On the other hand, a high gain setting will result in poor contrast and a late detection due to masking of the target blip by noise return. Use of the red viewing lens at night will require minor gain adjustments to produce optimum contrast and detection range.

Existence of various types of clutter on the scope (sea return, STAE, and side lobe clutter) may also require a reduced gain setting to detect the target.

To a minor extent, the gain setting will vary with pilot preference. Some pilots will "see" a target better with higher or lower gain settings than average. Generally, if the pilot is in doubt as to whether the gain setting chosen is the best, he should err on the low side. With a low setting, detection range may be sacrificed for clarity of scope; but if the setting is too high, detection range will probably be less due to low contrast.

B-bias Setting

The B-bias knob, on the left side of the radarscope, controls the background bias on the B-gun (target return) of the cathode tube. This is the only control that will adjust the brilliance of the acquisition bar and range strobe. The proper setting is the position that results in maximum target to background contrast. This lies between the faint illumination of the acquisition bar in a search mode and the appearance of a grass trace connecting the acquisition bar and the sweeping B-trace across the scope.

Tilt Control

Proper use of the tilt control critically affects radar performance. This is particularly true for targets which represent less than a 2 square meter radar reflectivity cross section (most jet fighters, for example).

The initial tilt setting should be based upon the altitude differential estimated to exist between the fighter and target. A handy rule-of-thumb is to use 1 degree of tilt for every 1,000 feet of difference in altitude at a range of ten miles. The angular settings are increased or reduced inversely with range. Accordingly, a target "UP 5,000" at 20 miles would call for a tilt setting of "UP 2.5 degrees."

If the target is within expected detection range, and return is seen within four sweeps, the tilt should be raised to a setting 2.5 degrees above the initial setting for four sweeps. If detection is still not obtained, a setting of 2.5 degrees below the initial setting should be tried. Up to 5 degrees above and below initial setting should be tried. Further excursions in tilt may be attempted, subject to the closing rate, level of pilot experience, and dependability of target altitude information.

In general, tilt control movement should be conservative. Excessive corrections are a common error. It is better to be too thorough in the coverage of a particular altitude band than to leave a "hole" in the scan pattern.

Fast Time Constant (FTC)

The FTC provision is of some assistance in improving target discrimination at low altitude over land. Activating the FTC sharpens the appearance of return echoes and reduces the amount of ground clutter. When the FTC is activated, gain must be readjusted because B-trace brilliance increases with a resultant reduction in scope contrast. FTC is of little value in reducing clutter caused by sea return. As with extensive ground clutter, scope clutter caused by clouds can also be reduced by the use of the FTC. FTC does not function in the pulse Doppler mode of the APQ-124.

Scope Clutter

Aside from the background noise return already discussed, the pilot may observe scope clutter due to ground return, sea return, STAE and side lobe effects. One major side lobe effect is the altitude line which is caused by primary ground return.

Ground Clutter

The amount and intensity of direct return from the land surface will depend upon fighter altitude, antenna tilt and type of terrain overflown. More ground clutter can be expected when flying over rougher terrain. Depression of the antenna below horizontal over land will usually result in large amounts of ground clutter. For this reason it is generally desirable for the fighter to be slightly below the target's altitude so that a level of "UP" tilt setting may be used. At mid-altitudes, 2,000 feet is a recommended altitude differential.

Second-Time-Around Echoes (STAE)

Although the radar displays only returns from targets within the selected scale, the transmitted power continues to travel outward until dissipated or absorbed. This transmitted power will also be reflected from targets at ranges greater than the selected scale. Such ranges are not displayed on the indicator. Returns from large targets at ranges greater than selected, may arrive back at the radar in time to be displayed at the same time the radar is receiving returns from the succeeding transmitter pulses. STAE are most prominent over land, but are also a problem at low altitude over water. Unlike the altitude line, they are returns in the main beam of the antenna and their presence is a direct function of the tilt position. When the tilt is such that the main beam is barely touching the ground at 68 to 88 miles, it will have the appearance of vertical bars.

Side Lobe Clutter

The radar antenna does not focus all of its energy in the main beam. Small fingers of stray power extend out from the sides of the antenna as shown in figure 1–40. The amount of power in the side lobes is small in proportion to the power in the main lobe. As an example, a target detectable at 20 NM in the main beam would not be detectable in the largest side lobe until it is within 1.6 NM. Some ground targets will return sufficient power to be received through the side lobes. These side lobe returns appear on the indicator as fuzzy bands at ranges greater than the altitude line. The range of the side lobe returns will naturally vary with altitude and tilt setting. Their occurrence is rare.

Altitude Line

The altitude line is a thin, bright, horizontal line extending across the scope at a range equal to the altitude of the airplane. It may present a problem during search and detection of targets whose range is nearly coincidental with that of the altitude line. Target definition in the vicinity of the altitude line can be improved by a slight reduction in the gain setting.

Test Targets

These artificial targets are spaced at 1,000-yard intervals and can be used as range markers. Also, each target is weaker than the preceding one so that they eventually become undetectable at longer ranges. The pilot can use these targets for inflight checks of system performance.

Before the test targets can be used as a reference for checking system performance, the normal performance of the particular radar must be known. The number of test targets detectable will vary from radar to radar although the radars will give the same performance on external airborne targets. Once a particular radar has been determined to be operating at peak performance and the number of test targets established, any reduction of that number will indicate a reduction of performance and a need for corrective action.

The most important inflight check that can be made using the test targets is lock-on sensitivity. The range of the smallest test target providing reliable lock-on should be established and used as the primary reference of range tracker and receiver performance.

AN/APS-67 PERFORMANCE

General

The AN/APS-67 radar set is capable of supplying basic information necessary to detect airborne targets as well as providing data to the fire control system to compute and display Sidewinder firing data and generate gun lead angles and aural firing tones. The radar set supplies target range, azimuth and elevation to the pilot within its limited search/track limits. The essential differences between APS-67 and APQ-83B/-124 are the 16-mile search range, no antenna tilt control other than positioning the aircraft nose in pitch, the acquisition and track being limited to a 7° cone about the boresight and an electrically controlled antenna. A properly tuned and aligned APS-67 should detect F-8 size targets at its maximum range.

Operation of the AIM-9C radar missile is not possible with AN/APS-67.

APS-67 Controls and Tuning

The basic concept of tuning any radar set to that condition which results in maximum target-to-background contrast holds true for the APS-67. The controls to do this are:

FOCUS–Adjust the focus control to the sharpest possible B-trace even though other symbols may appear fuzzy at times.

BRILLIANCE—A setting that yields a barely visible sweeping B-trace and sufficient illumination to yield a usable A-H bar is correct.

GAIN–Adjust the gain until the barely visible B-trace becomes a solid line with a faint return following it across the scope.

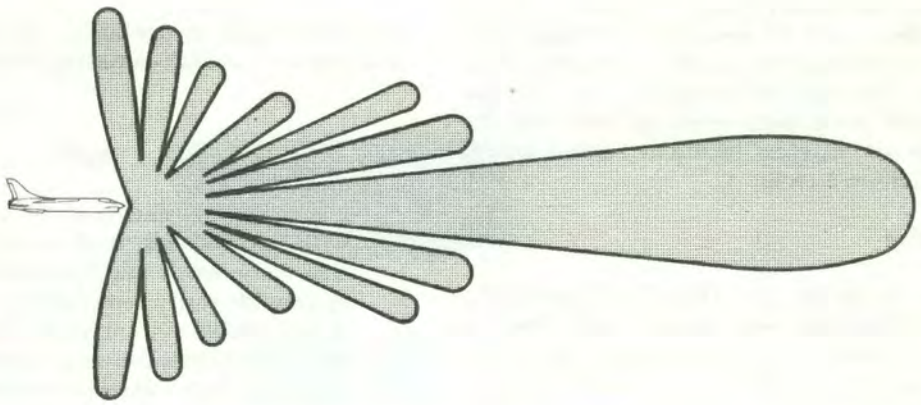
Note

The radar tuning switch should be in AUTO at all times except when encountering spot noise jamming.

TEST TARGETS–Can be used as described for APQ-83B/-124; however, no range rate is displayed.

FTC–Is essentially a search made clutter limiting device as described for APQ-83B/-124.

Typical Radar Antenna Lobe Pattern



AZ-31-10-66

Figure 1–40

APS-67 Search Capabilities

The APS-67 searches the same azimuth area as the APQ-83B/-124 (45° either side of boresight) but is limited to a one-scale maximum of 16 miles. The elevation coverage is a 14° cone (7° above and below boresight) that is the result of feedhorn nutation. The search pattern is a one-bar sweep (90° per second) that is roll stabilized. The only elevation control over the antenna is aircraft pitch maneuvering; however, the wide elevation beam provides excellent vertical coverage on all but pitch-up attacks.

APS-67 Acquisition

The acquisition mode of the APS-67 is entered by selecting RANGE on the radar control box. The antenna stops its azimuth sweep at boresight and enters a boresight acquisition condition (14° cone). The 2-mile sweeping range strobe can be positioned from 600 yards to a maximum of 8 miles with the minimum range control on the radar control box. Acquisition is only possible by first positioning the target to be acquired within the 14° cone in search and subsequently adjusting the minimum range control to sweep through the target blip.

APS-67 Track Capabilities

When the APS-67 enters the track mode, range track and angle discrimination are automatic within the 14° cone. The aircraft must be flown to maintain the target within this cone or the radar set will break lock. When this occurs, the power switch must be repositioned to SEARCH to reenter the search mode. The APS-67 scope displays are adequately covered in NATOPS and will not be discussed further here. The Sidewinder firing indicator (similar to the indicator in F-8H/J) is a part of the track display. On the meter is a track lamp that is illuminated in search and acquisition and goes out at lock-on (opposite APQ-83B/-124). An in-envelope lamp functions the same as APQ-83B/-124, however, the pilot must select the proper position on the missile release indicator box (starboard, aft console) which is labeled SW-1A (AIM-9B) or SW-1C (AIM-9D). Whenever SW-1C is selected, the valves on the range meter must be doubled due to the fact that AIM-9D capabilities often exceed the 30,000 feet maximum range depicted on the meter movement. The needles on the Sidewinder firing indicator operate the same as the APQ-83B/-124.

TARGET DETECTION AND ACQUISITION

SEARCH TECHNIQUES — APQ-83B

To attain skill at operating the APQ-83B, the pilot must have clear understanding of the antenna beam.

Note

The figures for antenna parameters given here will not coincide with actual specifications. The dimensions and facts have been chosen to provide easily remembered rules-of-thumb. Safety factors are included to ensure that no gaps in antenna coverage occur which would allow the target to remain undetected.

The stationary antenna with its reflector spinning can be considered an electronic searchlight with a field of view of 10 degrees as shown in figure 1–41. For the radar to detect, acquire, or track a target, this 10-degree beam must be placed on the target. To effectively use this beam, the pilot should be able to estimate the cross-sectional coverage per unit of range of this beam. This can be done if it is considered that the 10-degree beam will result in a circular coverage of 10,000 feet at 10 miles.

Using the relationship that the beam coverage is 10,000 feet at 10 miles, it can be estimated that the beam will illuminate a 20,000-foot circle at 20 miles, 15,000 feet at 15 miles, and 5,000 feet at 5 miles. If the antenna is pointed straight out along the horizon, it will be sensitive to targets within plus or minus 5,000 feet of the fighter's own altitude at ten miles. The depth of altitude coverage of the beam can thus be estimated at any range.

During normal search functions, the antenna is being programmed in azimuth to provide search coverage. The azimuth motion is roll stabilized so that it always stays level with the horizon regardless of the attitude of the fighter. The area covered by the search motion of the antenna will then be a rectangle, level with the horizon. At 10 miles, search coverage should be 10,000 feet deep and 14 miles wide, as illustrated in figure 1–42.

APQ-83B Radar Beam Coverage

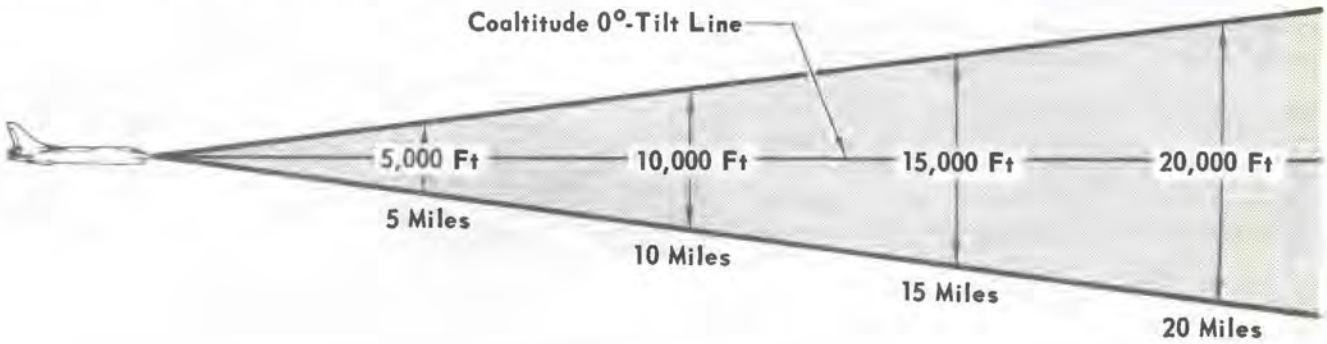


Figure 1–41

APQ-83B Radar Scan Coverage

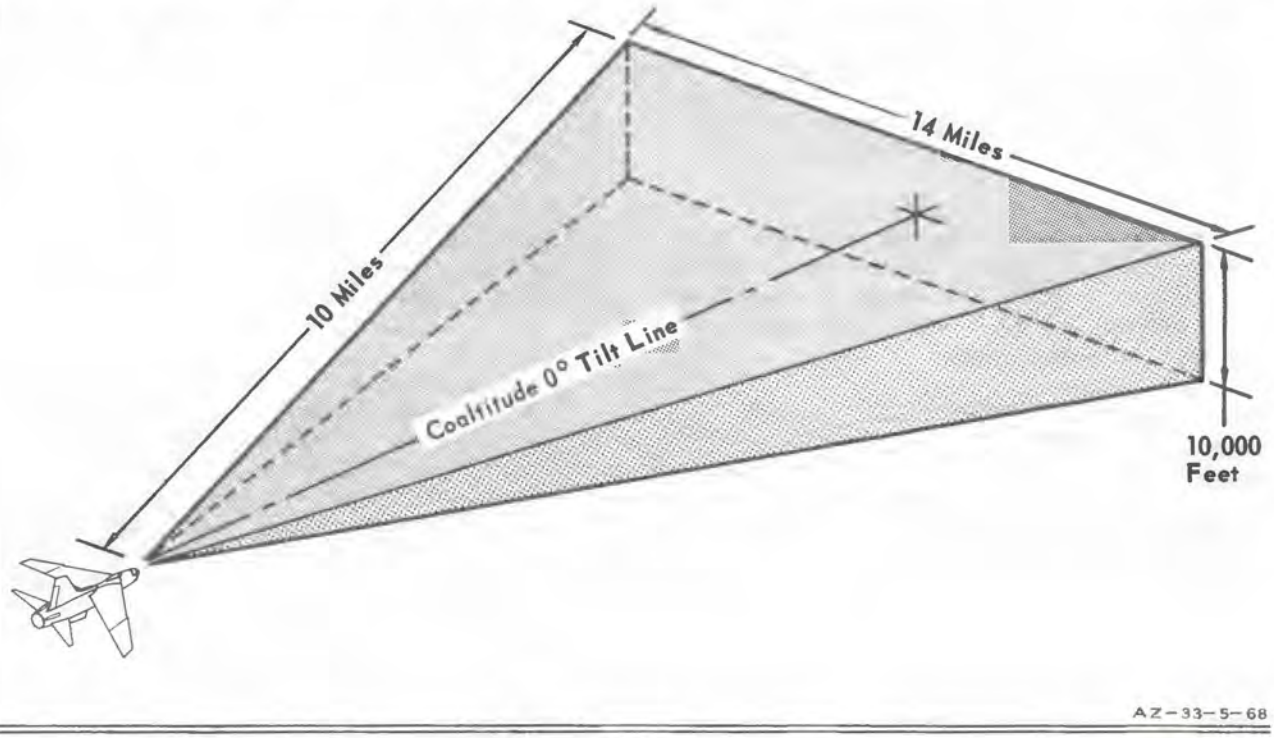


Figure 1–42

From this basic relationship, it can be estimated that the design search coverage should be 28 miles wide and 20,000 feet deep at 20 miles, 21 miles wide and 15,000 feet deep at 15 miles, etc. With right or left sector scan, the width of the search pattern is shortened accordingly. It should, however, be the technique of each pilot to attempt to center the radar to be coincident with the target for maximum detection.

The above relationship has been established with 0 degrees of tilt. In all search functions except ARO, this search coverage is pitch stabilized so that during climbs or dives it will always remain as set with respect to the earth (within the gimbal limits of the radar).

Note

The tilt mark on the indicator shows the angular relationship between antenna tilt and the true horizon.

Tilting the antenna up or down will move the search coverage pattern up or down. Attaining skill in using the tilt control is most important for early target detections.

At 10 miles, moving the tilt mark in 5-degree increments on the indicator will cause the search pattern to move 5,000 feet in altitude.

This tilt mark versus altitude differential can be used in two ways. If the altitude of the anticipated target is known, it can be used to tilt the antenna to immediately detect the target when it is within radar range. As an example, if CIC reports that the target altitude is 70,000 feet and fighter altitude is 40,000 feet, the following mental computation should take place:

If 5,000 feet equals 5 degrees at 10 miles, then 30,000 feet equals 30 degrees at 10 miles. Therefore, 30,000 feet equals 15 degrees at 20 miles and the antenna tilt should be adjusted to this setting.

The procedure of intermittently searching plus or minus 2.5 degrees on either side of the estimated tilt mark position would eliminate any possibility of the target's slipping through undetected. Such a procedure would result in a search coverage 28 miles wide and 20,000 feet deep at 20 miles.

This information can also be used to estimate the altitude of targets of opportunity. This is done by adjusting the tilt mark for strongest target return, noting tilt mark position and target range and converting back to altitude differential.

Note

There is a two-degree nod added to the search pattern which has been intentionally omitted in this discussion. This additional two degrees of elevation coverage can be considered a safety factor to cover the minor errors of the foregoing estimates.

SEARCH TECHNIQUES — APQ-124

To attain skill at operating the APQ-124, the pilot must have a clear understanding of the antenna beam.

Note

The figures for antenna parameters given here will not coincide with actual specifications. The dimensions and facts have been chosen to provide easy to remember rules-of-thumb. Safety factors are included to ensure that no gaps in antenna coverage occur which would allow the target to remain undetected.

The stationary antenna with its reflector spinning can be considered an electronic searchlight with a field of view of 7.5 degrees as shown in figure 1–43. For the radar to detect, acquire or track a target, this 7.5-degree beam must be placed on the target. To effectively use this beam, the pilot should be able to estimate the cross-sectional coverage per unit of range of this beam. This can be done if it is considered that the 7.5-degree beam will result in a circular coverage of 7,500 feet at 10 miles.

Using the relationship that the beam coverage is 7,500 feet at 10 miles, it can be estimated that the beam will illuminate a 15,000-foot circle at 20 miles; 11,250 feet at 15 miles; 3,750 feet at 5 miles; etc. If the antenna is pointed straight out along the horizon, it will be sensitive to targets within $\pm$3,750 feet of the fighter's own altitude at 10 miles. The depth of the altitude

coverage of the beam can thus be estimated at any range.

Note

The tilt mark on the right side of the indicator shows the angular relationship between antenna tilt and the true horizon.

Tilting the antenna up or down will move the search coverage pattern up or down. Attaining skill in using the tilt control is most important for early target detections. Accurate placement of the antenna in tilt can be accomplished if the following relationship is kept in mind.

At 10 miles, moving the tilt mark in 5-degree increments on the indicator will cause the search pattern to move 5,000 feet in altitude.

This tilt mark versus altitude differential can be used in two ways. If the altitude of the anticipated target is known, it can be used to tilt the antenna to immediately detect the target when it is within radar range. As an example, if CIC reports that the target altitude is 70,000 feet and fighter altitude is 40,000 feet, the following mental computation should take place:

If 5,000 feet equals 5 degrees at 10 miles, then 30,000 feet equals 30 degrees at 10 miles. Therefore, 30,000 feet equals 15 degrees at 20 miles and the antenna tilt should be adjusted to this setting.

The procedure of intermittently searching plus or minus 2.5 degrees on either side of the estimated tilt mark position would eliminate any possibility of the target's slipping through undetected. Such a procedure would result in a search coverage 28 miles wide and 20,000 feet deep at 20 miles.

This information can also be used to estimate the altitude of targets of opportunity. This is done by adjusting the tilt mark for strongest target return, noting tilt mark position and target range and converting back to altitude differential.

During normal search functions, the antenna is being programmed in azimuth to provide search coverage. The azimuth motion is roll stabilized so that it always stays level with the horizon regardless of the attitude of the fighter. The area covered by the search motion of the antenna will then be a rectangle level with the horizon. At 10 miles, the search coverage should be thought of as 7,500 feet deep and 14 miles wide, as illustrated in figure 1–44.

From this basic relationship it can be estimated that the search coverage will be 28 miles wide and 15,000 feet deep at 20 miles; 21 miles wide and 11,250 feet deep at 15 miles; etc. With right, left, or center sector scan, the width of the search pattern is shortened accordingly. It should, however, be the technique of each pilot to attempt to center the main radar lobe to be coincident with the target for maximum detection. The above relationship has been established with 0 degrees of tilt. In all search functions, coverage is pitch stabilized so that during climbs or dives it will always remain as set with respect to the earth (within the radar gimbal limits).

Note

This discussion applies to the 1 BAR-SPIN search condition of the APQ-124. Whenever 1 BAR-NO SPIN is selected, the beam parameters are reduced by approximately 2° (the nutation). Conversely, whenever 2 BAR-SPIN is selected, these parameters are increased by approximately 2° (the nod). Approximate APQ-124 vertical beam widths are:

1 BAR-NO SPIN 5.5°
1 BAR-SPIN 7.5°
2 BAR-SPIN 9.5°

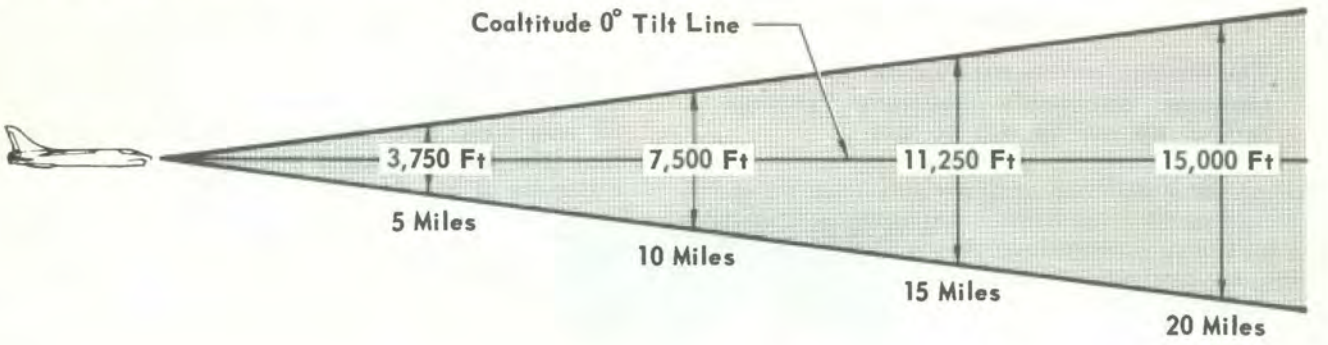
SPOTLIGHTING

The pilot should use the acquisition mode to manually search (spotlight) the area in which a target is expected. This should be done when the target is near the range limits of the radar. The target may be expected because of CIC information or because it was thought to have been observed during sweep of the antenna in the search mode. The antenna azimuth and elevation should be cycled through a small sector. Care must be taken to hold the sweeping range gate in a clear area or the radar will automatically lock onto clutter or the altitude line. Once located, a target should be manually tracked with the radar in the acquisition mode until target video is of sufficient brightness to allow contact in the search mode in the appropriate sector scan. Thus the target and the surrounding area can be investigated until lock-on is desired.

SECTOR SCAN

The sector scan feature of the radar should be used when initially looking for a target but a return to wide search should be made after good detection. Sector scan approximately doubles the radar energy

APQ-124 Radar Beam Coverage

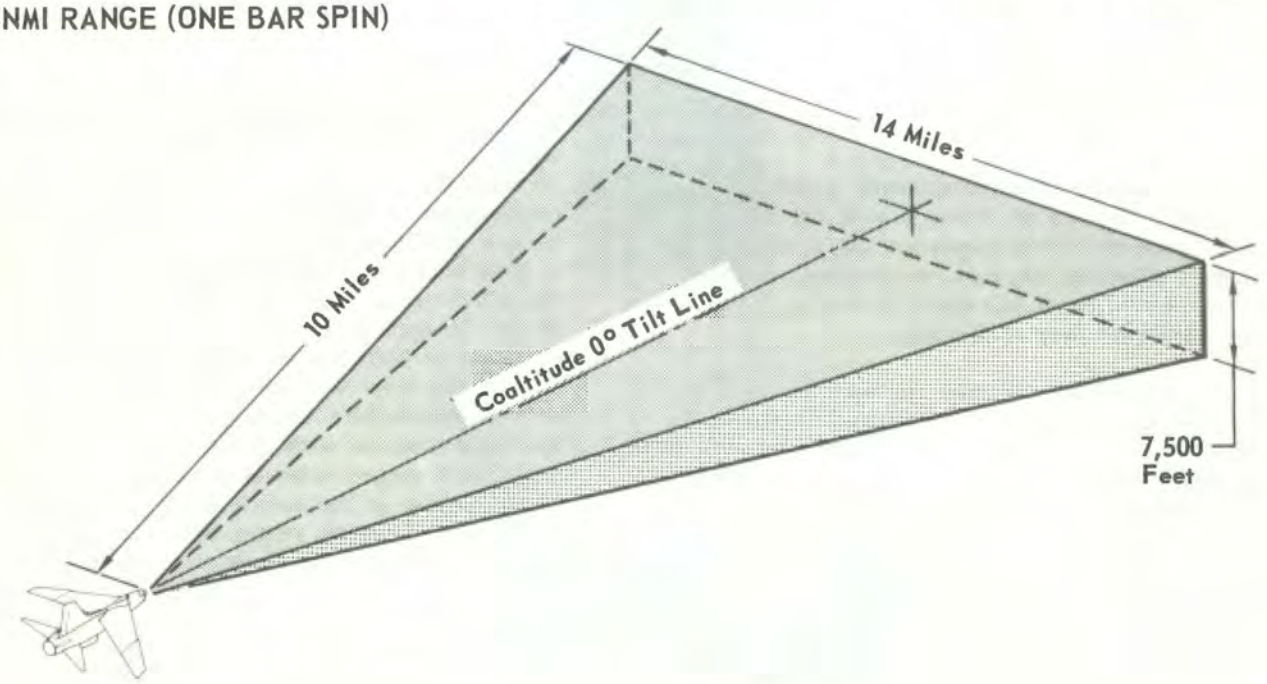


AZ-34-5-68

Figure 1–43

APQ-124 Radar Scan Coverage

10-NMI RANGE (ONE BAR SPIN)



AZ-35-5-68

Figure 1–44

transmitted to the selected area in a given time interval and thus improves the detection capability. The return to wide search permits a survey of a larger area for multiple targets which may not have been detected by CIC.

ACQUISITION TECHNIQUES

Lock-on in a beam attack should be delayed until steering information is needed to properly execute the conversion or attack. This gives the pilot the opportunity to investigate the presence of multiple targets or enemy cover.

When the range strobe is positioned such that it sweeps through the illuminated target in the collapsed B-trace, range tracking begins and the T-lamp will light. A perceptible delay may occur before the angle tracking circuitry is ready to track; when this occurs, the indicator display will automatically change to the track presentation. The optimum technique for acquiring a lock-on, time permitting, is to preposition the range strobe over the target in azimuth only, being careful to keep the sweeping range strobe in a clear area in range, preferably beyond the target. Track the target manually for a few seconds while carefully adjusting tilt to obtain the best target possible in the collapsed B. This procedure additionally allows time to closely examine the area about the target for possible multiplane targets. When satisfied with tilt adjustment and the target area appears clear, the range strobe can be slowly positioned to overlay the target in range to obtain the track presentation.

Immediately after lock-on, range rate should be compared with expected target speed and heading and the F-8 speed and heading. This will allow early rejection in the event the wrong target has been selected. The radar should be closely monitored after lock-on. The radar can lose lock-on (noted by loss of T-lamp) and provide erroneous steering information before automatically returning to search. If this steering information is followed, the intercept can easily be missed.

APS-67 TECHNIQUES

The vertical beam coverage of the APS-67 is significantly greater than either APQ-83B or APQ-124, and as such allows greater chance to detect targets within the 16-mile maximum range for a target of known altitude. This is offset by lack of an effective tilt control when attempting to locate targets of unknown altitude. It follows then, to effectively utilize the limited capabilities of the APS-67, every effort should be extended toward giving the pilot, via CIC, accurate target altitude information. In absence of target altitude information, the pilot must periodically pitch the aircraft up or down to extend the vertical search pattern. Use of two aircraft at low and medium altitude also contributes to the search capabilities of this system.

TRACK MODE ANALYSIS

RADAR TRACKING

The primary purpose of the APQ-83B/APQ-124 radars is to guide the pilot to a successful target intercept. The search function of the radar provides initial target detection and course intercept steering information. The latter is strictly a function of the operator's ability to correctly interpret the B-scope presentation and to visualize the intercept geometry. The tracking function provides for refined intercept information and enables the pilot to close the target to the firing position for the type of weapon selected.

The missile release problem is one of maneuvering the aircraft to a point in space where the missile can reach the target after it is launched. Success will generally depend on the skill of the pilot and proper interpretation of the scope presentation. Target range can be determined by viewing the position of the range strobe in the collapsed B-trace. Target closing rate can be determined by the position of the V_c gap.

Target altitude can be estimated by relating target range and antenna elevation angle above the artificial horizon. Missile climb capability can be estimated by relating target range and the length of the calibrated vertical. Missile launch altitude can be estimated by relating target range, the gap between the lower end of the calibrated vertical and the artificial horizon, and the fighter's own altitude. All of the above relationships have two standard scale factors: 5 degrees equals 5,000 feet altitude differential at 10 miles, and 1 inch equals 45 degrees.

During any missile launching maneuver, the pilot should boresight the target by centering the aiming dot inside the steering circle. Only when the dot is within the circle will the target be within the field of view of the AIM-9B missile. AIM-9C missile tone may be expected when the aiming dot appears on the

scope face and the target is within ⅓ to ¼ initial detection range. AIM-9D tone may be heard when the dot is within one circle radius of the steering circle. The missile tone must be heard and the in-envelope light must be on prior to release. The in-envelope light will not come on unless all three of the following conditions are satisfied:

a. The fighter must be within the computed non-maneuvering target envelope.

b. The g limitations of the missile are not exceeded.

After launching the missiles, the fighter need no longer follow the steering information presented on the scope. When an AIM-9C missile is fired, fighter maneuvers after launch are restricted by the requirement that the radar continually illuminate the target during the time of the flight of the missile. Thus, fighter maneuvers are limited by the antenna tracking limits (±45 degrees in azimuth; +45 degrees and −30 degrees in elevation) about the LOS (line-of-sight) to the target.

When either a Sidewinder AIM-9B or AIM-9D missile is fired, there are no restrictions on fighter maneuvers after firing.

STEERING INFORMATION

The target's angular position relative to the aircraft's ADL will be shown on the indicator by the steering circle and aiming dot. The circle and the dot both display the same angular information, and the only difference between the two is one of scale factors. The scale factor for the course circle is 45 degrees per inch while the scale factor for the dot is about 9 degrees per inch. To aim the ADL at the target, it is necessary to steer the aircraft so that the dot is centered in the circle. An approach continued with this relationship would result in a pure pursuit approach to the target.

At angles greater than 9 degrees, the aiming dot will be deflected too far to be seen on the indicator (except on IP-626 scope), and all steering and determination of target position will have to be read by noting the steering circle's position relative to the center of the indicator face.

A rough determination of the target's altitude advantage can be obtained by noting the steering circle's position relative to the A-H bar. If the A-H bar bisects the steering circle, then the target is co-altitude. The altitude advantage of other than co-altitude targets can be determined by estimating the distance between the center of the circle and the A-H bar and converting by using the relationship of ⅛ inch or 5 degrees equals 5,000 feet at 10 miles.

Since the steering circle shows antenna position, the tilt mark is not seen on the indicator during tracking functions.

ARTIFICIAL HORIZON

The A-H bar adjustment in the track mode is disabled and its position represents the true horizon.

AGC EFFECTS

At longer ranges the strength of the radar target return will vary a great deal during the tracking run due to fade, scintillation, and changes in aspect angle. The automatic gain control of the APQ-83B and APQ-124 will attempt to keep the target size constant as seen by the range tracker. This will result in a variation of the amount of receiver noise present on the narrow B of the track presentation. A strong target return may eliminate receiver noise completely from the collapsed B, while a weak signal may cause the narrow B to become very bright with the receiver noise. For this reason, at long ranges which give weak returns the pilot must stay alert to the possibility that the radar may unlock from the target. By watching the collapsed B for excessive receiver noise, the experienced pilot will be able to determine when the radar is in danger of breaking lock. The final indication that the radar has broken lock will be the extinction of the T-lamp. Because of the fading phenomena of the target at long ranges, it is better to delay lock-on until fading as seen on the search picture is no longer present.

RANGE RATE INFORMATION

The APQ-83B has a range rate gap in the steering circle and the APQ-124 has a separate, large diameter, stationary closing-velocity circle. In both systems the left, or counterclockwise edge (with the gap at 12 o'clock), is the index. Each clock code digit in the clockwise direction represents 200 knots closing velocity. (Example: The index at 2 o'clock represents 400 knots closing.) If the initial motion of the range rate index is counterclockwise, the velocity is opening. The V_c index can be calibrated for zero position by locking on a test target.

The range rate gap, properly interpreted, provides an additional dimension to the intercept picture available to the pilot. By comparing displayed range rate data with available air control information, the following determinations are possible:

a. Surface target lock-ons (range rate equal to fighter ground speed)

b. Shift locks to altitude line or surface targets

c. Abrupt target jinking (changing aspect with respect to fighter)

d. Rough determination of type of target (prop or jet)

MISSILE AERODYNAMIC FIRING DATA

The missile release computer determines the non-maneuvering Sidewinder aerodynamic firing envelope for the pilot.

Theoretical envelopes for Sidewinder AIM-9B, AIM-9C and AIM-9D have been computed and mechanized into the computer. A generalized discussion of the functions developed is contained below.

The envelope of the Sidewinder missile should be thought of as moving with the target. If the fighter is within the missile envelope and the missile is "seeing" the target, the missile can be launched and will be able to guide to the target.

Four parameters define the envelope limits. These are the guidance time limit, the velocity or range limit, the g-limit of the missile, and the seeker look angle or lambda-limit. These parameters thus define missile maximum and minimum ranges, and angle-off limitations. The computer receives inputs of range, and range rate from the APQ-83B or APQ-124, static and total pressure from the pitot-static system, and airplane g load from an accelerometer in the computer.

The empirical relations defining the envelopes in *terms of maximum and minimum ranges only* are electrically mechanized in the computer by means of magnetic amplification circuits and diode-shaping networks. The pilot, by selecting a particular station (and thereby the type of missile on that station), sets the computer into operation computing the range envelope for the particular Sidewinder selected.

When the airplane is within the computed range envelope, the in-envelope light on the radar scope illuminates indicating that the missile can be fired provided it is "seeing" the target and the pilot has satisfied angle-off firing limitations. BAT mode provides direct target and missile maximum range read out in feet on the Sidewinder Firing Indicator.

The theoretical envelopes have been calculated for a 90 percent confidence level for all models of the Sidewinder to allow for production missile performance variances.

It is often tactically desirable to take advantage of the missile's climb capabilities against a higher-flying target. This has been provided for in the computer group.

The pull-up envelope is a function of the missile and airplane aerodynamic capabilities. To successfully perform the pull-up maneuver, the pilot must know if he is in position to pull up, acquire the target with the missile, and fire.

To do this, the computer displays the calibrated vertical, which is a differential altitude indicator on the radar scope. The length of this line is a function of the altitude differential, target range, and aircraft-missile climb capabilities. If the bottom of the calibrated vertical is on the radar artificial-horizon, the missile-aircraft combination is capable of intercepting the target.

The missile release computer is instrumented for pull-up attack from the tail aspect only.

CALIBRATED VERTICAL

During radar tracking with a missile station selected on the armament control panel, an electronic line is displayed extending down from the steering circle toward the artificial horizon bar. The length of the calibrated vertical represents maximum permissible missile climb angle relative to the horizon. The length of the line is determined by:

a. Type missile selected
b. Target altitude above fighter (antenna elevation angle plus range)
c. Closing velocity

As mentioned the calibrated vertical line is controlled by the missile release computer. When the length of the calibrated vertical reaches the A-H bar, a successful pitch-up can be made; however, the target must be within R_{max} or the antenna elevation must be 30 degrees.

It is important to remember that when the calibrated vertical just reaches the A-H bar, the above mentioned pitch-up allows for only 20 degrees of heading change to obtain missile tones or angle off. For a 90-degree turn it is necessary to increase Mach number by 10 percent. If the calibrated vertical does not reach the A-H bar, it is possible to increase its length by:

a. Closing range
b. Cruise climbing (holding speed)
c. Increasing speed

BREAKAWAY DISPLAY

Whenever the combination of range, range rate, and missile performance data from the missile release computer is such that the selected missile cannot be fired due to minimum range, the breakaway "X" will appear on the scope. The "X" is composed of the calibrated vertical and the A-H bar and is only possible with a fuselage or wing station selected and the gun selector switches in the OFF or center position.

Note

Once the breakaway "X" appears, it will disappear if the fighter slows down and decreases the range rate or increases the target range which puts the fighter back in the missile envelope.

Steering information remains valid after the appearance of the breakaway "X" (APQ-124 and APQ-83B). Since missile minimum range is not presently displayed with either the APQ-83B or APQ-124 system, an appreciation of minimum range is mandatory; otherwise, the pilot will realize unexpected illumination of the breakaway "X." Generally, regardless of the type missile selected, computed missile minimum range varies from 3,000 to 4,000 feet in a 1.2:1 overtake situation, co-altitude, within 20° angle off. An appreciation for this range can be accomplished in practice by noting target range on the lower needle of the ID-1485 Sidewinder firing indicator or by acquiring co-speed airborne targets utilizing the EX-16 gun range tones system, and noting the position of the target against the range mark bezel on the left side of the scope. Since the cathode ray tube in the radar scope is subject to vertical alignment, this position may vary from aircraft to aircraft.

APS-67 TRACK MODE ANALYSIS

The track mode (RANGE function) of the APS-67 is limited to 8 miles in range within a 14° cone. The display is a circle that at 8 miles just touches the crows feet on the scope bezel. As range is decreased the circle collapses, until at two miles, it is in coincidence with the etched circle on the scope bezel. The aiming dot, when centered, indicates the target is on boresight. As a target departs the boresight line in angle (any direction according to the clock code), the aiming dot reaches the outer limit of the scope whenever the target reaches 3.5° off boresight. If the target continues away from the boresight line, the aiming dot moves back toward the center of the scope. When the target is 7° off boresight, the aiming dot is again at the center of the scope. Further excursion of the target off boresight would result in a broken lock-on.

No range rate is displayed on the radar or Sidewinder rangemeter other than noting the speed that the circle or needle moves down its respective scale.

Missile release data is obtained from the Sidewinder firing indicator as previously described.

It should be obvious that the limitations of the APS-67 system require modified pilot techniques. Rapid determination of target altitude by CIC and positioning the aircraft at slightly below coaltitude is required for detection. Operation after detection should be primarily in the search mode due to the narrow angle of discrimination in track until such time as lock-on is desired for fire control data.

APQ-124 EXTENDED CAPABILITIES

The HOJ function in the APQ-124 yields the same capabilities at HOJ in the APQ-83B. However, in this mode in the APQ-124, the range strobe is stationary. This feature will allow much greater chance for expeditious head-on, high closure rate lock-ons. This capability will also have certain applications in air-to-air ECCM.

The antenna control allows the pilot complete versatility in all range scales while operating in conventional pulse. It will be possible to select any of the

sweeping options in any range scale while also enjoying the capability of locking-on in any range scale at any antenna control position. This capability has effects upon long range air-to-air detections, which should be increased using one bar–no spin option (providing the pilot is aware of the critical tilt control required). Radar mapping will be possible in one bar–no spin in all range scales.

The BAT mode in APQ-124 overrides all other options provided the function switch is in the pulse operating condition. Whenever BAT mode is selected, the pilot receives Pulse BAT regardless of position of the antenna control switch or the range scale.

The emergency position of the function switch allows the pilot to pick up a mechanical-electrical latch that overrides all radar set safety sensors when the switch is repositioned to PULSE.

CAUTION

The function switch emergency option should be used in a combat situation only. Total destruction of the radar and/or a nose compartment fire could result.

The radar set safety sensors will be returned for use when the function switch is repositioned to the STBY or OFF position.

INTERCEPT TECHNIQUES

Positioning a fighter aircraft into the launch envelope for successful weapon delivery requires a certain amount of standardization with respect to intercept turns and voice communications. Other considerations that call for specific tactics or techniques are altitude of the enemy or fighter and the approach to target aspect. It is the purpose of this section to explore the advantages and disadvantages of each ingredient of an air intercept as it stands alone. This leaves the fighter pilot the versatility to build his own intercept from individual techniques as the tactical situation dictates. The ECM section will cover the combined techniques required for intercepting an enemy aircraft in an ECM and evasive maneuvering environment.

INTERCEPT TURNS

General

To optimize intercept control it is necessary that the fighter adhere to standardized turn radii and rates of turn. The latter is the parameter used to make intercept turns predictable, with the resulting turn radius the same for all aircraft at a given airspeed. This is taught to fleet air controllers and is programmed into tactical data system computers. Inconsistent and nonstandard turns make intercept control difficult and create a requirement for continuous heading adjustment throughout the intercept to reestablish proper geometry. Remember, excess aircraft handling detracts from radar detection.

Turn Criteria

Turn criteria are defined as follows:

a. *60-Degree Angle of Bank* — A significant turn where the radius is not as critical as getting the aircraft turned expeditiously to heading. It is used:

1. On an initial vector from a combat air patrol pattern
2. On a reattack following a forward hemisphere lead collision attack
3. When in excess of 1.4 IMN

b. *45-Degree Angle of Bank* — Only used on canned antiparallel offset intercepts such as broadcast control.

c. *1.5-Degree/Sec (½ SRT)* — Is a positioning turn used between combat air patrol stations and when the pilot takes control of the intercept ("JUDY"). To realize a 1.5 degree/sec positioning turn the following formula is used.

$$1.5 \text{ degrees} = \frac{1091 \text{ Tan Angle of Bank}}{\text{TAS}}$$

Selected altitudes and airspeeds yield the following bank angles:

Altitude	*TAS*	*IMN*	*Angle of Bank (Degrees)*
SL	420		30
10 M	450	0.71	32
20 M	500	0.81	34
30 M	525	0.90	35
40 M	575	1.0	38

The fighter pilot must have a seaman's eye feel for these bank angles and double check with the turn needle, and time versus heading, to fly as close as possible to a ½ SRT. Essentially ½ SRT lies between 30 to 40 degrees angle of bank for most operating areas of the F-8.

d. *3-Degree/Sec (SRT)* — Is also used as a positioning turn as outlined above whenever the controller calls for "HARD" or "TIGHTEN" turns. By the same method, the following selected angles of bank are valid:

Altitude	*TAS*	*IMN*	*Angle of Bank (Degrees)*
SL	420		49
10 M	450	0.71	51
20 M	500	0.81	54
30 M	525	0.90	55
40 M	575	1.0	57

A knowledge of these bank angles is also necessary. The turn needle may not be completely reliable and should be used only as a cross-check with the bank angle.

e. *As Necessary Turn* — Used whenever the pilot takes control of the intercept ("JUDY") to effect the lead or pure pursuit techniques desired. This type of turn varies from shallow turns to high "g" steep turns as the situation dictates.

Summary

The standard turns utilized in intercept geometry have been outlined. It is important to emphasize the "As Necessary" turn because no intercept should be derogated due to standardization. Whenever the fighter pilot recognizes a necessary corrective action he should take it and advise the controller of his new heading. A 1.5-degree/sec (½ SRT) is recommended if the controller gives "TURN TO BOGEY HEADING" and the pilot does not yet have radar or visual contact. Using the rate of turn formula, a graph can be easily constructed showing desired turns and corresponding angles of bank throughout the flight envelope. When using supersonic techniques less than 1.4 IMN, logic would dictate turns less than 60 degrees bank angle, but greater than ½ SRT for positioning.

PILOT/CONTROLLER INTERCEPT COMMUNICATIONS

The following is a sample of the close control intercept communications procedures.

Note

All information transmissions made by the controller will end in "OUT." Order transmissions will end in "OVER" and will be acknowledged by the fighter.

Transmissions from Controller to Fighter

a. Vector for bogey. The initial vector and the transmission is always started with the full call sign. The word VECTOR is used if the fighter's heading is unknown when the run is started. If the fighter is on a known heading, the controller will direct a port or starboard turn to the intercept heading.

Example: Heading unknown — "Lightning One this is Ruthless Ruth, vector two five zero for bogey, over."

Heading known — "Flash One this is Ruthless Ruth, starboard two five zero for bogey, over."

b. Magnetic bearing and distance to bogey.

Example: "One, bogey two nine zero fifty, out."

c. Bogey heading and speed.

Example: "One, bogey heading one six zero, speed point nine five, out."

d. Bogey composition and altitude.

Example: "One, bogey single target, altitude high, out."

As a guide to estimating altitude the following table is used.

Very low:	0 – 2,000 feet
Low:	2,000 – 10,000 feet
Medium:	10,000 – 25,000 feet
High:	25,000 – 40,000 feet
Very high:	40,000 and above

e. Fighter speed and altitude assignment.

Example 1: Controller — "One, speed and angels as desired, over."

Fighter — "One, speed point nine five angels thirty five, out." (Controller's transmission speed and angels as desired is an interrogative, requiring fighter response.)

Example 2. Controller — "One, speed point nine five angels thirty five, over."

Fighter — "One, speed and angels set."

f. Bogey crossing.

Example: "One, bogey crossing right to left, out."

g. Bogey position.

Example: When fighter steady — "One, bogey forty right thirty five, out."

Example: When fighter turning or heading is unknown — "One, bogey two nine zero thirty five, out."

Transmissions Between Fighter and Controller

a. Contact.

Example: Visual contact—"One, tally ho, three o'clock five miles, three MIG-21's, over."
AI contact — "One, contact thirty right thirty, over."

b. Contact confirmed or negated.

Example: "One, that is your bogey, heading one six zero speed point nine five, out."

Example: "One, negative, bogey is forty right thirty, out."

c. Judy. When the fighter wishes to assume control of the intercept, he will transmit "JUDY" to the controller.

Example: "One, Judy, over."

The controller will acknowledge this transmission and continue to monitor the intercept. Radio silence is maintained by the controller.

Example: "One, Roger Judy, out."

If the pilot desires to modify his Judy, he may do so by transmitting "Judy, continue bogey dope." The controller will then continue to transmit bogey's position in magnetic bearing and distance.

d. Bogey jinking.

1. Bogey jinking in heading.

Example: "One, bogey jinking right, out."
"One, bogey now heading one eight zero, out."

2. Bogey jinking in altitude.

Example: "One, bogey diving/climbing, out."
"One, bogey altitude now twenty five, out."

3. Bogey jinking in speed.

Example: "One, bogey accelerating/decelerating, out."

"One, bogey speed now one point two, out."

e. Confirm target. If the fighter and bogey tracks plotted by the controller following "JUDY" indicate the possibility of the run being made on the wrong target, the controller will transmit "CONFIRM TARGET," followed by the bogey position.

Example: "Cactus One, confirm target. Bogey two nine zero fifteen, over."

If this information confirms the target acquired as the bogey, the fighter will repeat "JUDY." If the target acquired is not the bogey and the fighter desires further control, he will transmit "LOST CONTACT" and present heading.

f. Lost contact. Should the fighter lose contact with the bogey or for any reason desire further control following "JUDY," broke lock, jamming, etc., he will transmit "LOST CONTACT."

Example: Fighter — "Ginmill One, lost contact, heading two three zero, over."
Controller — "One, bogey two seven zero ten, out."
Fighter — "One, heading two three zero, out."
Controller — "One, port one eight zero bogey heading over."
Fighter — "One, port one eight zero, out."

g. No contact. Occasionally it is necessary to search left or right of the assigned vector to investigate the airspace. This usually occurs during periods of intermittent GCI/CCI coverage. The procedure is initiated by the controller transmitting: "Check Right" or "Check Left." The fighter turns 30 degrees from the base vector in the called direction and stabilizes for a minimum of four sweeps on the new heading while closely monitoring the radar scope. If there is still no contact, the fighter immediately returns to the base vector, reporting when steady.

h. The following are assumed speeds that may be requested by a controlling agency:

1. Saunter — Maximum endurance (rarely tactically feasible.)
2. Liner — Maximum range (usually minimum used CAP speed)
3. Buster — Maximum MRT speed (about 0.96–0.98, throttle can be retarded to hold 0.96–0.98 after initial acceleration.)
4. Gate — Maximum CRT speed (implies most rapid acceleration to supersonic speed desired, then modulate throttle to hold.)

i. Other transmissions non-essential to the intercept:

1. Lost communications procedures
2. Parrot check
3. State reports
4. Weather
5. Pigeons
6. Steer
7. Armament switches check

INITIAL VECTOR

The primary objective of the initial vector is to position the fighter between the vital area and the raid much as a ball player guards the goal. When the fighter has been positioned on the "radial" of the raid from the vital area, it then can either be run out on the radial to engage, or held on the radial until the enemy commits himself to an attack. This provides maximum protection combined with the tactical feasibility of reserving fighter strength for enemy raids that actually turn in and threaten the vital area. The initial vector from a CAP station is flown using a significant turn (60 degrees of bank) unless the tactical situation demands a maximum rate of turn which requires a nose-down, pull-to-buffet technique using afterburner.

RUN-OUT SPEED

The run-out speed selected for the initial vector is a very important element. The F-8 is capable of speeds over 900 KTAS. However, high speeds use a lot of fuel, require the fighter to be at a high altitude, and are very critical to GCI/CCI error.

The selected run-out speed should satisfy three fundamental criteria:

a. It should place the intercept as far out as reasonably possible.

b. It should provide the fighter with sufficient basic speed to match the raid maneuvers and to permit the fighter to commence the attack phase.

c. It should accomplish the first two with a minimum depletion of the combat fuel package.

A cursory examination of run-out speeds would seem to imply that the highest possible speed should be selected to complete the intercept as far out from the vital area as possible. A more detailed study of the problem reveals that within the present environment of early warning ranges and enemy threats, the supersonic run-out does little to reduce raid penetration. This is illustrated in figure 1–45.

The same information is presented in more detailed graphical form in figure 1–46. Figures 1–46 and 1–47 reveal that for typical early warning ranges of about 200 NM and a 0.8 IMN non-maneuvering raid, a 1.5 IMN run-out only reduces the raid penetration about 12 miles. However, the additional combat fuel required to obtain those 12 miles is about 3,700 pounds. The

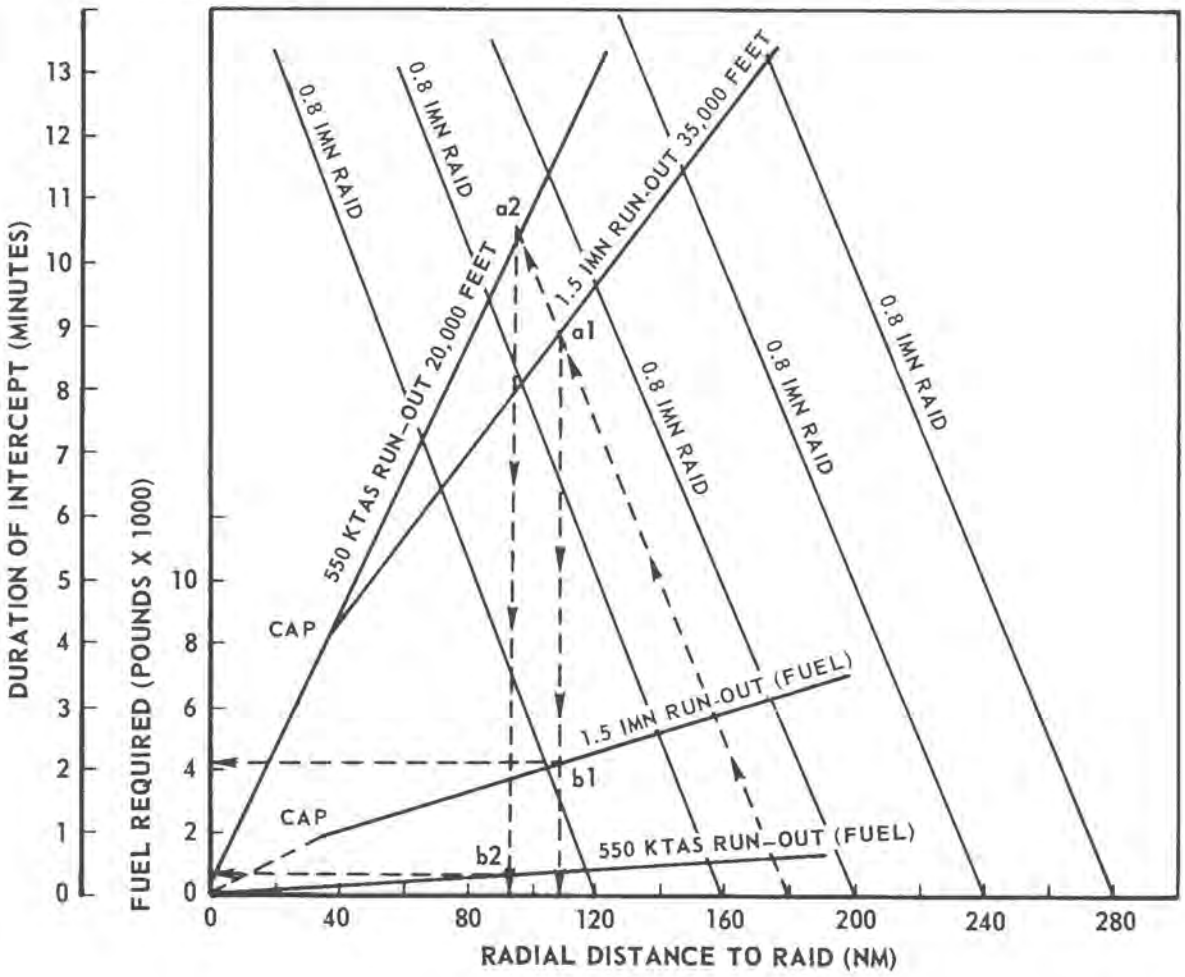
Raid Penetration and Combat Fuel vs Initial Vector Run-Out Speed

Raid Distance At Initial Vector NM	Distance At Intercept NM		Combat Fuel Consumed Pounds	
	Run-Out 550 KTAS 20,000 Feet	Run-Out 1.5 IMN 35,000 Feet	Run-Out 550 KTAS 20,000 Feet	Run-Out 1.5 IMN 35,000 Feet
40	22	20	190	900
80	43	45	370	2200
120	65	72	570	2800
160	87	97	750	3800
200	109	121	940	4600

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Figure 1–45

Raid Penetration vs CAP Speed and Combat Fuel Consumption



SAMPLE PROBLEM

0.8 IMN Raid at 180 NM. What will be raid penetration and combat fuel used for cap speeds of 550 KTAS and 1.5 IMN?

ANSWER (FOLLOW DOTTED LINES)

a. Raid Penetration
   (1) 1.5 IMN = 110 NM
   (2) 550 KTAS = 92 NM

b. Combat Fuel Used
   (1) 1.5 IMN = 4200 Pounds
   (2) 550 KTAS = 700 Pounds

AZ-40-10-66

Figure 1–46

normal combat fuel package of a CAP F-8 is approximately 3,000 pounds, assuming a 90-minute cycle time. Therefore, the expenditure of 3,700 pounds to reduce raid penetration by 12 miles leaves no reserve for reattacks or reassignment to other raids.

TIME (MINUTES)	SPEED (MACH NUMBER)	AVERAGE SPEED (MACH NUMBER)
0	0.9	0.9
1	1.05	0.98
2	1.15	1.03
3	1.24	1.08
4	1.38	1.12
5	1.50	1.20
6	1.50	1.24
7	1.50	1.28
8	1.50	1.30
9	1.50	1.32
10	1.50	1.34

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Figure 1–47. Average Speed During 1.5 IMN Acceleration and Runout

The reason that the difference in raid penetration for the two run-out speeds is relatively small is that the average run-out speed lags the actual run-out speed for several minutes, as illustrated in figure 1–47. The difference in raid penetration in a forward-hemisphere initial vector is the result of the changes in the average speed of the fighter. For example, if two airplanes, separated by 100 miles, fly toward each other at co-speed, they will meet at the mid-point or 50 miles from either starting position. In order to shift the meeting point by only 10 percent (10 miles) in either direction, one of the airplanes must increase its average speed by 50 percent. To reduce raid penetration by 10 percent, the initial separation between the accelerating fighter and a subsonic raid would have to be almost 200 miles.

The tactical speed of the fighter during the run-out should permit rapid response to changes in vectors caused by raid jinking and GCI/CCI errors, and provide sufficient speed at the end of the initial vector to commence the attack turn. The attack turn against a jinking raid requires that the fighter be co-speed, or faster than the raid, to ensure any reasonable probability of arriving within the missile launch envelope.

A true airspeed of 500 to 550 knots (380 to 420 KIAS) at about 20,000 feet is a relatively high run-out speed but allows a maneuvering potential and reasonable fuel specifics. The use of this speed/altitude combination is particularly suitable for run-out against medium altitude, subsonic raids. The attack turn against a subsonic, medium altitude raid does not require speeds in excess of 550 KTAS. A supersonic raid in the relatively limited early warning confines of a task force environment will usually be characterized by a high closing rate and a short time to intercept. When vectored against a supersonic raid, the F-8 should normally commence acceleration immediately. This is necessary, since in most cases the attack phase, which will probably start shortly after the initial vector, requires co-speed or faster for a reasonable probability of successful arrival at missile launch position.

For medium altitude targets, a 1.2:1 speed advantage is sufficient to allow the F-8 to complete a rear-hemisphere Sidewinder attack. Therefore, it may not be necessary to use CRT during initial run-out vectoring provided sufficient warning range is available. Figure 1–48 gives the fighter-to-target range at which CRT must be selected to arrive at an attack position with the desired speed advantage assuming the run-out is head-on to the target.

RUN-OUT ALTITUDE

Selection of run-out altitude should be based upon target altitude, the distance between fighter and target, maneuverability and speed desired, and the desired final attack phase altitude. Run-out altitudes are further discussed in subsequent paragraphs.

MEDIUM ALTITUDE TECHNIQUES

Against medium altitude targets, every attempt should be made to provide the pilot with current target altitude information.

The antenna tilt should be elevated so that STAE and ground clutter are either faint or non-existent. This will normally occur with two to three degrees "UP" tilt. If rough terrain tends to produce heavy STAE and ground clutter effects, the fighter altitude should be reduced sufficiently to allow centering of the target in the radar beam with the tilt setting necessary to avoid scope clutter. No more than five degrees of "UP" tilt should be required under the most extreme conditions. In this event a 5,000-foot altitude disadvantage for the fighter will provide adequate detection capability to a range of 15 miles for fighter-type targets (two square meters). Bomber targets should be detected at ranges of 18 to 20 miles on the APQ-83B and at 30 to 40 miles on the APQ-124.

CRT Selection for 1.2 to 1 Speed Advantage at Intercept

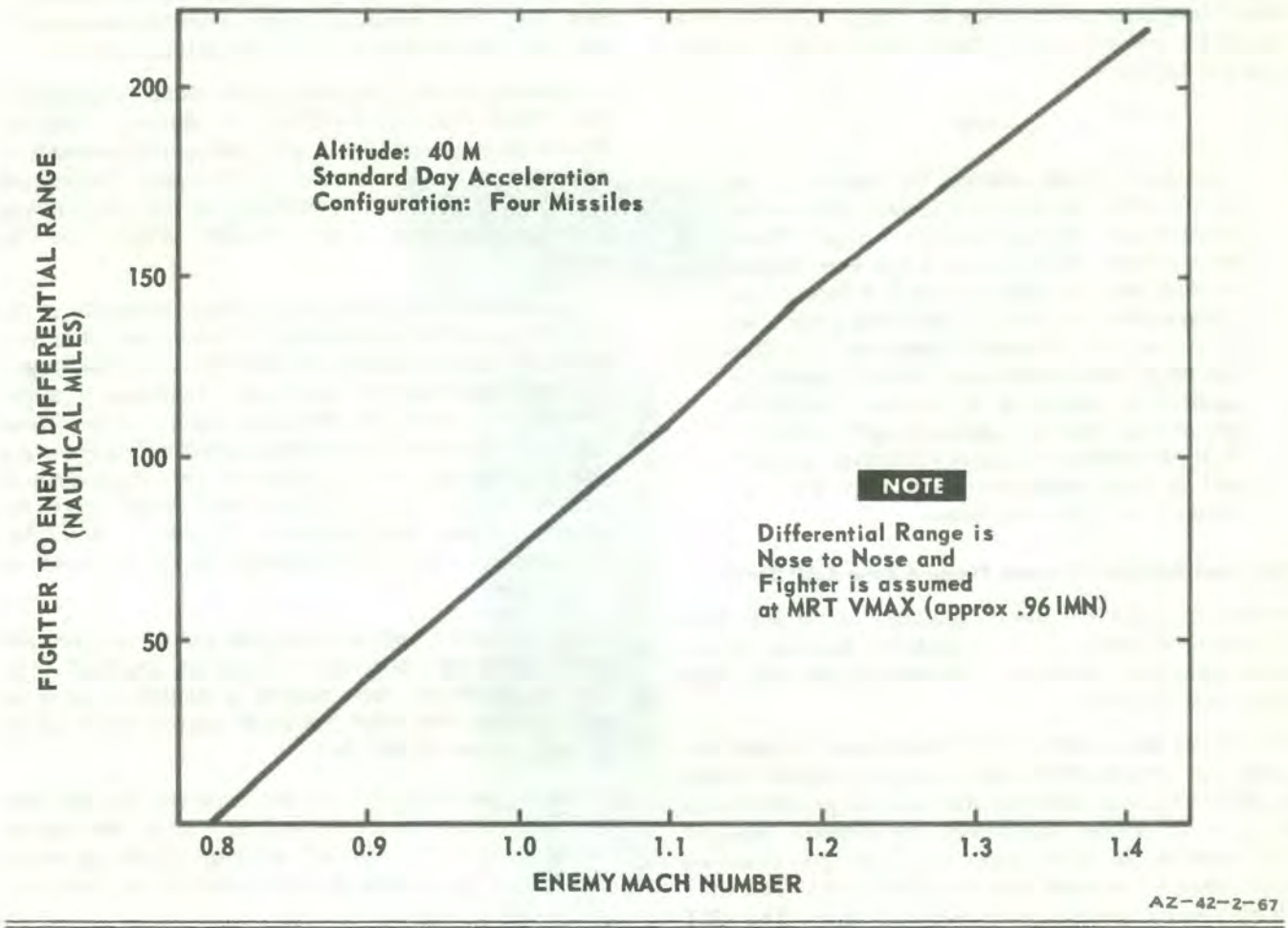


Figure 1–48

The fighter should have an altitude disadvantage of from 2,000 to 5,000 feet for the following reasons:

a. Radar performance is increased by the reduction in clutter and STAE effects with slight antenna look-up angles.

b. IR contrast for missile detection is better against a sky background than against the horizon or surface.

c. The fighter is afforded a greater element of surprise in the six o'clock low attack.

The maximum AIM-9B range against the medium altitude raid with a 1.2:1 speed ratio is approximately three miles. The horizontal envelope is free of lambda and g-limits out to about 45 degrees angle-off. It is recommended that firing occur within 40 degrees angle-off at a range of about two miles. If the intercept is carried in to one mile before firing, the angle-off must be reduced to less than 20 degrees because of missile launch g limitations.

Note

Whenever possible every attempt should be made to fire Sidewinder missiles with as low an angle off as possible.

If the fighter is well into the final attack turn and has not obtained target detection visually or on radar, the fighter should immediately slow to the speed of the target to maintain at least a 3 to 5 mile nose-tail separation. If detection has not occurred by this time, there is a strong possibility that the target altitude information is in error. Although slowing the

fighter to target speed is undesirable, it is necessary if the target is to be detected. The nose-tail separation of three to five miles places the fighter outside normal target defensive armament range and provides for radar elevation scan coverage for target detection. The use of the autopilot is recommended for all but final attack tracking.

Note

This part of the manual, as stated in the introduction, is oriented toward all-weather (non-visual) interception of a target. However, timely visual contact is the best method to terminate any fighter attack. Pilots should always strive to convert displayed radar data to a "tally-ho" whenever possible. This does not imply that valid scope displays should be ignored at ranges or in weather conditions where detection of targets is highly unlikely. This philosophy is valid at all fighter altitudes and at night where contrails have been detected in starlight conditions.

Medium Altitude Target From A Low CAP Station

Because of the CRT climb capability of the F-8, CAP stationing altitude has no significant bearing on the basic intercept geometry. The same turns and offset principles are used.

For the sea level CAP, a CRT climb must be made because the time-to-climb and distance covered during an MRT climb to medium altitudes are prohibitive in terms of the initial target-to-fighter distance required. For example, an MRT climb to 35,000 feet from sea level takes 11 minutes and covers 80 miles. The CRT climb takes 3 minutes and covers 20 miles. The CRT climb consumes 400 pounds more fuel, but this has to be accepted under most conditions.

HIGH ALTITUDE TECHNIQUES

High altitude (25 to 40 M feet) techniques are substantially the same as medium altitude techniques for subsonic targets. The F-8 has excellent performance throughout this range. A 1.2:1 fighter to bogey speed ratio is recommended. Generally the F-8 will CAP below this range and cruise climb to two to five thousand feet below the target during run-out.

VERY HIGH ALTITUDE TECHNIQUES

For very high altitude targets (above 40,000 feet), the best fighter altitude is between 35,000 and 40,000 feet. At 45,000 feet, the CRT fuel consumption is less than that at 35,000 to 40,000 feet; however, acceleration is much slower and level flight V_{max} is substantially reduced. For very high altitude subsonic targets, 35,000 feet gives the best MRT performance for fuel consumption, V_{max}, and maneuverability prior to commencing the CRT acceleration to achieve pitch-up speed.

Consideration must be given to the climb capability of the missile because it affords the fighter a distinct advantage in initial launch positioning and provides an extension of weapon system performance. Utilization of the missile's climb capability is the only means whereby extremely high altitude targets can be engaged.

Although the basic beam/stern attack geometry is applicable to attack positioning for this type of target, the final position should be directly astern the target. The desirable position astern as a function of target altitude and speed is shown in figure 1–49 These ranges are based on the recommended fighter-to-target speeds of figure 1–50. Against the very high altitude subsonic target, the air controller should give the fighter the speed recommended in figure 1–50 so that the necessary speed is developed to enable the pitch-up to be made.

It is extremely important that the fighter be vectored astern the target to within 20 degrees angle-off. The pitch-up to fire at these targets is actually a zoom to gain altitude; the pilot has little control with which to track above 50,000 feet.

If the target detection has not occurred by the time the range astern has closed to 6 or 7 miles, the fighter should commence a "blind" pitch-up. Radar or visual acquisition must then be attempted in the pitch-up.

A successful pitch-up to within the missile envelope should be possible if either of the following combination of indications is satisfied:

a. The calibrated vertical extends below the artificial horizon and the target is at less than maximum missile range, or

b. The calibrated vertical extends below the artificial horizon and the antenna look-up angle is 30 degrees.

The pitch-up is a 2g maneuver to a climb angle of about 30 degrees for maximum gain in altitude, or to that angle required to boresight the target. Figure 1–51 is the vertical AIM-9D missile envelope for a Mach 1.2 fighter versus a Mach 0.8, 60,000-foot target. It can be seen that the missile significantly extends the capability of the weapon system. If the fighter can

Desired Range Astern for High Altitude Tail Attacks

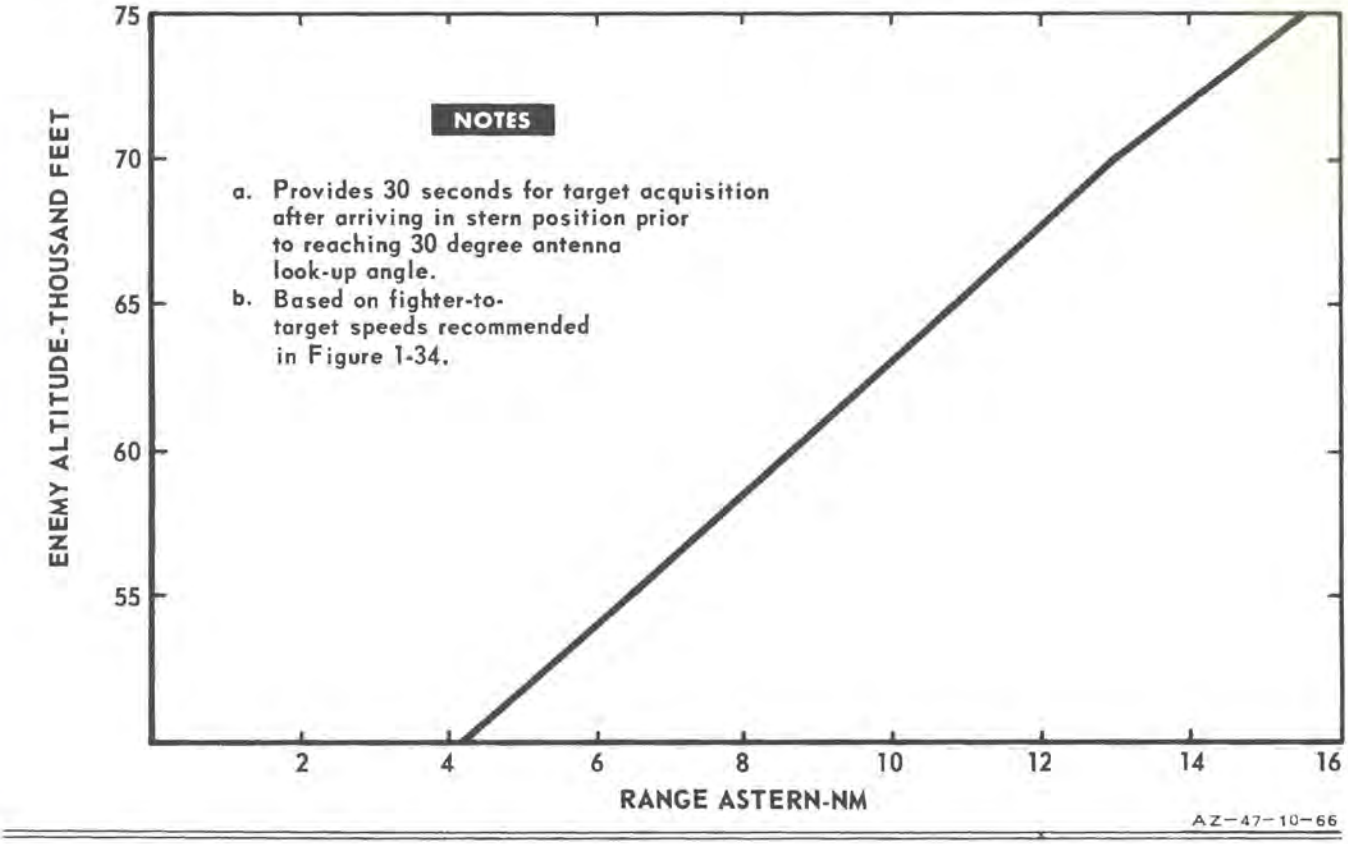
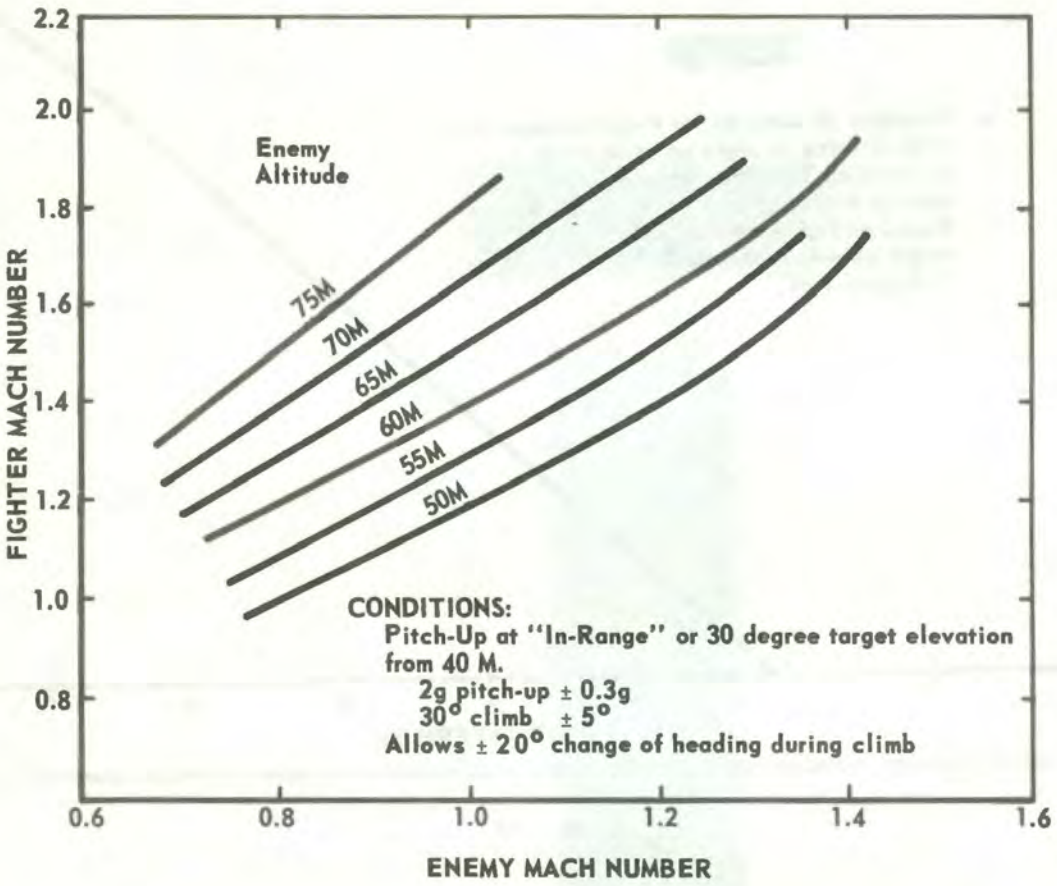


Figure 1–49

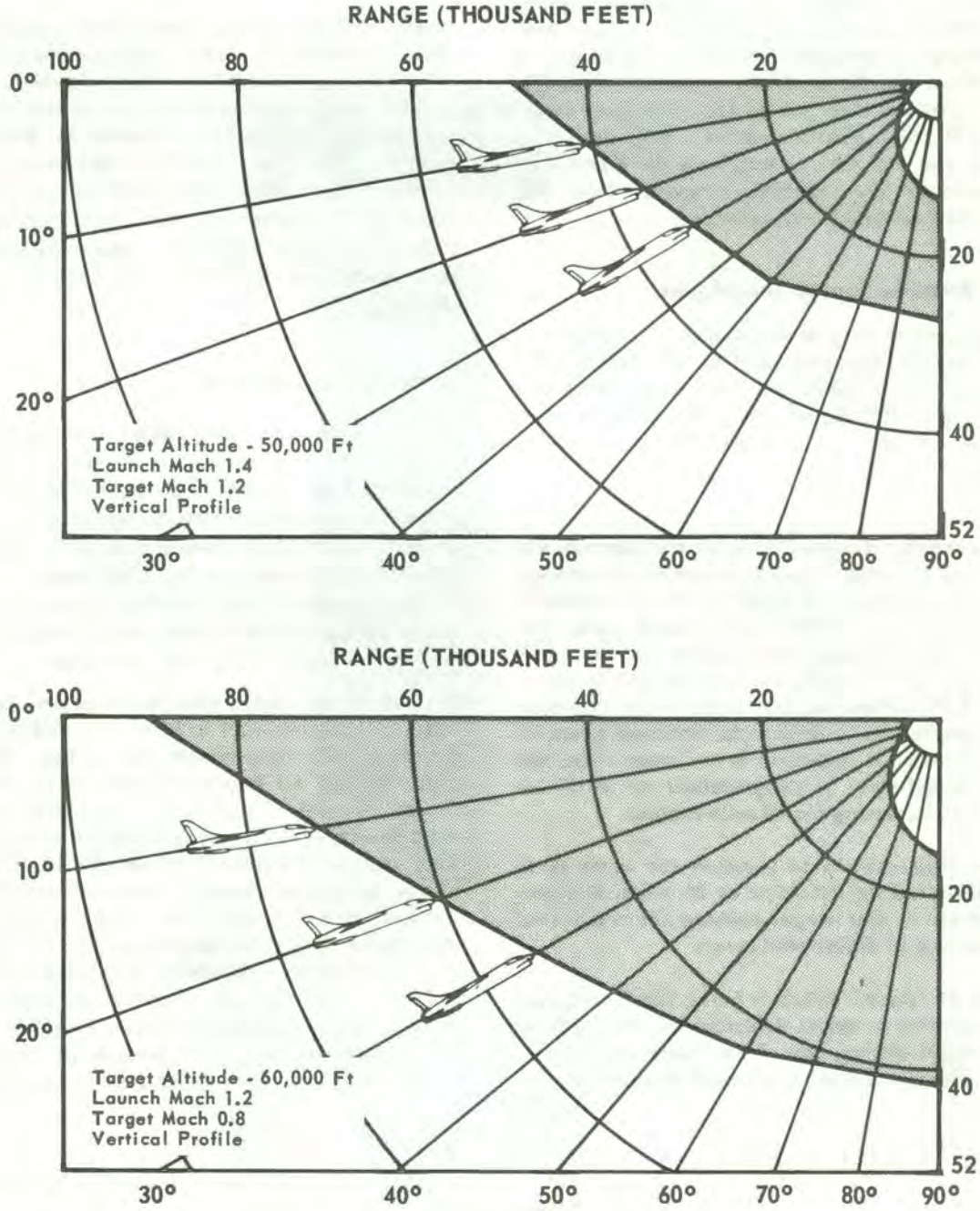
Desired Fighter Speed for Very High Altitude Attacks



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Figure 1–50

Sidewinder AIM-9D Vertical Profile Envelope



AZ-46-5-68

Figure 1–51

obtain missile tone in a 30-degree climb, and is within the vertical envelope, it can still fire.

As stated previously, the pitch-up is essentially a zoom maneuver to reduce the altitude differential. Associated with it are afterburner blowouts, low indicated airspeeds, and a mandatory negative g recovery. The question of when to begin the recovery will depend upon the tactical situation. It will be a natural tendency to attempt to continue the climb and boresight the target. However, the pushover necessary should be commenced at no less than 300 KIAS. It has been found that 80 to 150 knots may be lost in a 0.5g pushover. Commencing the pushover at less than 300 KIAS may very well lead to low indicated airspeeds "over the top," with the associated consequences.

Very High Altitude Search Techniques

Search techniques at very high altitudes are primarily dictated by the problem presented by the altitude differential between the fighter and the target. With target altitudes up to 30,000 feet above that of the fighter, judicious use of the tilt control during search is required.

One recommended procedure is to set the antenna tilt for detection at 15 miles, based upon predicted altitude differential. For example, in figure 1–52, the predicted altitude differential is 20,000 feet. Based upon the antenna tilt rule-of-thumb (one degree equals 1,000 feet at a range of 10 miles), the antenna tilt is set at 15 degrees "UP." Then, as the target range closes, it should be detected as it enters the antenna beam at a range of 15 miles. If detection is not made then, the tilt should immediately be programmed up to 20 degrees, the required setting for 10-mile ranges.

An alternate procedure is to position the antenna at the setting required for detection at 20 miles. If detection is not made at that range, antenna tilt is adjusted up, corresponding to differential range.

If a pitch-up or "zoom" attack is being conducted and is commenced prior to target detection, it is possible to detect the target during the zoom maneuver by tilt adjustment. The tilt control is adjusted throughout the climb to attempt to center the target in the search beam.

Sidewinder Missile Employment

A description of Sidewinder missiles and performance envelopes is contained in Part 6 of this section.

With a fighter overtake speed, the missiles have better than a 10,000-foot climb capability at high altitude. This will allow the F-8 to attack targets at altitudes up to 60,000 feet with some degree of effectiveness. This effectiveness is practically eliminated, however, if the pilot pursuit-tracks to boresight the target. The ability of the F-8 to effectively maneuver to pursuit-track above 50,000 feet is very poor. Therefore, the high altitude attack must be of the form of a lower altitude positioning run, followed by a pitch-up to boresight the target.

SUPERSONIC TARGETS

The F-8 with any of the Sidewinder family of missiles can make an attack against supersonic targets. This intercept will involve high fighter Mach in order to obtain the necessary overtake speed which will result in high rates of fuel consumption. Pitch-up techniques are usually not required for high altitude (twenty-five to forty thousand feet) supersonic intercepts if the F-8 is positioned within 10,000 feet of the target altitude with at least a 1.2:1 speed advantage.

Because of the high speeds involved and large turning radii, the pilot cannot expect early radar detection of the target. For this reason and to keep from getting "sucked," the air controller must retain more precise control during a supersonic intercept. On a beam-stern attack it is best to lead the intercept even more than intuition dictates because the high closure rate of the fighter will quickly diminish midway through the final turn. If a tail chase results, target penetration and fighter fuel consumption are increased. For example, if the fighter is sucked into a trail position of 8 miles, it must close to about 2 miles before missile release. The 6 miles which must be made up will require an additional 1,200 pounds of fuel and result in an additional 30 miles of raid penetration.

Single Tilt Setting for High Altitude Target

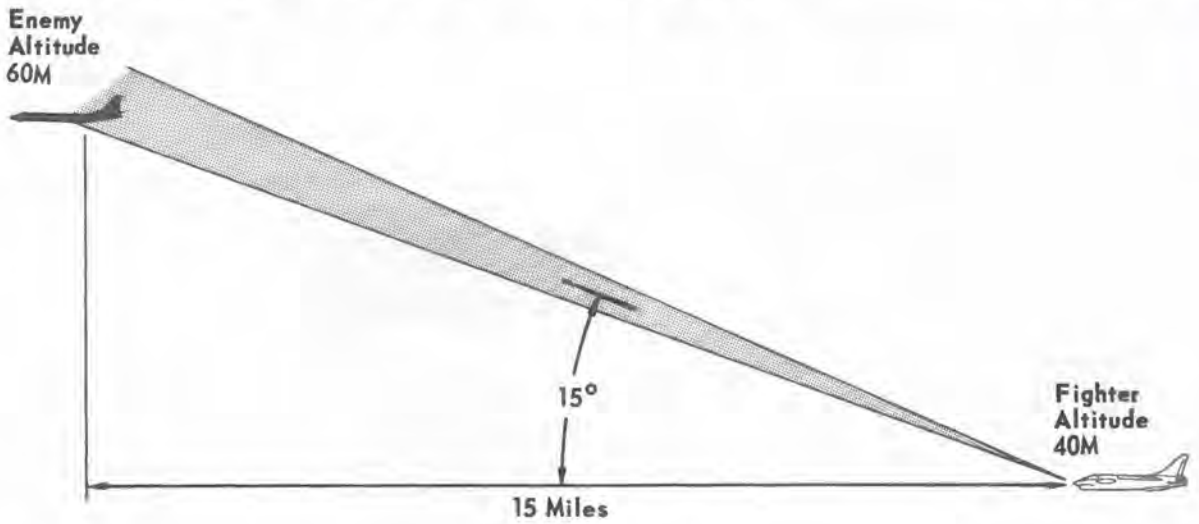


Figure 1–52

Very High Supersonic Targets

If the target is above 45,000 feet, a pitch-up attack will be required since the airplane cannot accelerate and sustain Mach 1.4 above 45,000 feet. Best acceleration performance is at 40,000 feet and below. The difficulties encountered in the pitch-up attack can best be explained through an example. Figure 1–51 is the vertical AIM-9D missile envelope for a Mach 1.4 attack against a Mach 1.2 target. Assuming a target at 50,000 feet and a pitch-up commenced at 40,000 feet at a range of 3 miles (when the elevation antenna angle is up 30 degrees), the airplane can easily arrive in the allowable firing envelope. A 2g, 30-degree pitch-up at Mach 1.4 will result in a speed decay to Mach 1.2 (or co-speed) at 45,000 to 47,000 feet altitude. The co-speed firing envelope is smaller than that of figure 1–51. If more than a 10,000-foot altitude differential exists, the severity of the problem is increased. If time permits, fighter speed should be increased to the maximum attainable in order that target closure can be maintained during the pitch-up to boresight. As previously mentioned, it is recommended that the pitch-up be commented when the antenna elevation angle is up 30 degrees. If further closure is made, the possibility exists that the antenna may exceed its gimbal limits and radar tracking will be lost. The pitch-up should be made from as directly astern as possible. The ability to maneuver for tracking rapidly degrades during the pitch-up as airspeed diminishes.

As the aiming dot appears at the top of the radar scope, stick back pressure must be reduced or an overshoot will result. The required climb angle to boresight the target reduces rapidly as altitude is gained in the pitch-up. The recovery technique should be a negative g pushover because the combination of low indicated airspeeds and large aileron deflections of the wing-down recovery method can easily lead to a stall/spin if attempted.

LOW ALTITUDE TECHNIQUES

At target altitudes of 2,000 feet or less, the fighter can no longer depend upon a lower approach altitude and elevated beam to avoid scope clutter. The APQ-83B and APQ-124(pulse) radars have an extremely limited search capability at low altitudes over land. Over water, the radars are capable of performance essentially the same as that obtained at high altitudes.

Over Land

STAE and ground clutter can be expected to cover the upper portions of the scope. At best, a four- to five-mile relatively clear area may exist between the ground return noise (zero to 2 miles) and the STAE and the heavy ground clutter. FTC and low gain settings should

be used to reduce the ground clutter. Small deviations from an optimum focus setting will increase the detection problem to a larger extent than at higher altitudes. The best radar performance at low altitudes over land can be obtained under the following conditions:

a. The fighter, if able to remain above 2,000 feet AGL, should attempt to achieve a lower altitude than the target. Thereby an "UP" antenna tilt can be used. This will reduce ground clutter and STAE.

b. If possible, approach the target so as to avoid hilly or mountainous radar background.

c. If the target is below 2,000 feet AGL, the antenna tilt control during search should be programmed to start above predicted target altitude. Antenna tilt should then be reduced in minute increments in an attempt to detect the target on the lower antenna sweep.

d. Lower than normal gain settings can increase detection probabilities by reducing scope clutter and STAE, obviously with the sacrifice of longer detection ranges.

Over Water

The APQ-83B and APQ-124 radars have a good search capability at low altitudes over water, subject to the conditions described in the following paragraphs.

Sea Return

Sea return will be seen on the lower portion of the scope out to ranges determined by:

a. Fighter Altitude. Sea return will vary inversely with altitude. At fighter altitude of 1,000 feet, normal sea states will produce sea return out to ranges of four to five miles. Sea return becomes excessive when searching for low altitude targets which are lower than the fighter.

b. Gain. Increased gain settings will produce a corresponding increase in sea return. At short ranges the gain should be reduced in order to allow target detection in the area normally covered by sea return.

c. Sea State. The extent of sea return will vary directly with the sea state. With normal gain setting and heavy seas (sea state of four), sea return clutter will be seen to a range of approximately 10 miles. Under calm sea conditions, sea return may extend to only one or two miles.

Second Time Around Echoes

STAE returns will be seen at low altitudes over water. It is observed on the lower portion of the scope and its extent varies directly as the fighter altitude. Like sea return, it is affected by gain, altitude, and sea state.

Fast Time Constant (FTC)

Use of the FTC setting is of little aid in target detection over water unless heavy weather or precipitation conditions exist.

Atmospheric Refraction

At low altitudes under normal atmospheric conditions, APQ-83B and APQ-124 radar performance is comparable to that at higher altitudes. However, under abnormal indices of refraction, detection ranges may be very limited and fade areas may exist. It has been observed that this poor radar performance occurs when a subrefractive index of the gradient of refraction exists in layers at or lower than the fighter altitude (target below). Because index of refraction data will probably be unavailable to the pilot in a tactical situation, the best course of action is to vary the fighter altitude between 1,000 and 2,500 feet if poor radar performance is incurred at low altitude.

Low Altitude Run Out

If the raid is low, the fighter must also be low, from both attack and radar search considerations. In order to take full advantage of the low altitude capability of the APQ-83B and APQ-124 radars, the fighter should be afforded a 15- to 20-mile detection opportunity. As stated previously, a look-up antenna tilt is desirable to reduce ground clutter and STAE. For extremely low altitude targets, a fighter attitude of 1,000 feet is the most desirable. It is the best compromise between low altitude radar performance and a reasonably safe fighter maneuvering altitude.

The descent to 1,000 feet from a CAP altitude of 20,000 feet requires from one to three minutes, depending upon weather, darkness, and pilot capability. It is highly desirable for the fighter to be level, at or near the final attack altitude, when 30 miles from the target. This allows the pilot to orient himself, adjust radar gain and antenna tilt, and assume final attack speed, prior to having to commence the radar search phase.

Generally, task force detection ranges of low altitude targets are relatively short, thus requiring a rapid descent to low altitude. A safe procedure is to make a speed brake descent with 80 to 85 percent rpm. The following table gives recommended descent attitudes.

DESCENT ATTITUDE

Altitude (Feet)	*Attitude (Degrees)*
40,000 to 20,000	−30
20,000 to 10,000	−20
10,000 to 7,500	−15
7,500 to 5,000	−10
5,000 to 2,000	− 5

The speed brake is retracted as necessary to gain the desired attack speed and altitude. The descent from 40,000 feet requires about 4.5 minutes and from 20,000 feet, about 2 minutes. The distance covered from 40,000 feet is 25 to 30 miles and from 20,000 feet, 15 to 20 miles.

Note

To arrive at 420 KIAS at 2,000 feet requires speed brake refraction at about 8,000 feet.

VERY LOW ALTITUDE TARGETS

Very low altitude targets are considered to be those at an altitude of less than 2,000 feet. 1,000 feet is considered to be the optimum F-8 altitude for the intercept of very low altitude targets. It is the optimization of best radar performance with safe aircraft maneuvering. Successful intercept of very low level targets as low as 100 feet is possible using beam-stern or beam-stern conversion techniques. HEAD-ON intercepts of very low targets are NOT recommended. Missile launch envelopes are more restricted at low altitude, therefore every effort should be toward an acute turn to target heading versus getting sucked into a prolonged tail chase. Zero angle-off is the optimum position for low altitude missile firing.

Very Low Altitude Fighter Geometry

The basic problem is much more critical than at higher altitudes. Although the attack geometry is similar to that for higher altitudes, the problems which the pilot and air controller must cope with are much more severe. The pilot is confronted with low altitude maneuvering at high indicated airspeeds. The problem of radar operation and monitoring is made more difficult by the fact that much more attention must be paid to aircraft control. Whereas vertigo can be discomforting at higher altitudes until reorientation occurs, vertigo at 1,000 feet or less can prove fatal. Because the capability of surface radars for long range detection and control is limited, the air controller is faced with many problems. The confines within which the intercept must take place may be very limited. Voice communications with the fighter may be weak and intermittent. Because of the short low altitude detection ranges, the first intercept must be successful as there will probably not be enough time or distance available for a reattack.

Unless daylight visual conditions prevail, it is much safer to establish instrument flight procedures and adhere to them. It is highly recommended that the autopilot be used. It affords a high degree of pilot relief to the benefit of improved radar operation. The autopilot may be used up to the time at which the pilot assumes manual control to boresight the target for missile release.

Once radar lock-on has been made, the dot must not be centered in the steering circle until within maximum missile range. The boresight criteria of the aircraft are such that the radar boresight line is almost parallel to the wing chordline. Since the aircraft flies at a positive angle of attack regardless of airspeed, the flight path is always at a downward inclination to that of the target when it is boresighted. If the aiming dot is centered throughout a low level intercept, collision with the surface could occur. For all low altitude targets, it is safer to center the aiming dot in azimuth and maintain at least 1,000 feet of altitude until inside missile maximum range. The dot should then be centered, missile tone obtained, and the missile fired followed by immediate recovery.

The missile release computer is instrumented for a minimum target speed of Mach 0.6 which is approximately 400 KTAS. Although the initial design of the computer was predicated on higher altitude and speed conditions, the computer gives fairly accurate in-envelope indications at low altitude for AIM-9B and AIM-9D. For almost every condition, the in-envelope light will illuminate at or in excess of the extreme low altitude range limit of the AIM-9B. Therefore, it is best to wait (assuming a 50 to 100 KTAS overtake speed) approximately 10 to 15 seconds after the in-envelope light illuminates before centering the steering dot and firing.

Missiles will gravity drop about 275 feet after firing, and against a 100-foot altitude target, the low point in the trajectory will be about 50 feet lower than the target. To preclude the missile hitting the surface before target intercept, the fighter should be no lower than 400 feet at missile launch against a lower altitude target.

BASIC INTERCEPT GEOMETRIES

Several factors make up the ingredients that result in any particular intercept geometry. They are available weapons, detection opportunity, enemy composition and evasive tactics, quality of air control (human factors and equipment), acceptable raid penetration and fighter pilot proficiency level. Since all of these ingredients are not predictable, it is necessary to have procedures and techniques for omnidirectional approaches

to any target. A perfectly set up beam approach intercept geometry can rapidly degenerate into a front quarter and then a head-on approach by two simple jinking turns by the enemy.

This section includes the relative merits and techniques for beam, front quarter and head-on approach intercepts. Rear quarter and stern approach intercepts are not discussed as they require high fighter overtake velocities and are not consistent with the doctrine of maintaining the defensive fighters between the force to be protected and the attacking enemy raid.

Figure 1–53 depicts track crossing angles and the inclusive track crossing angles that define the various attacks.

INTERCEPT TERMINOLOGY

The following definitions are paramount to any discussion of intercept geometry. These should be thoroughly understood as they define specific tactical situations as well as certain techniques. See figures 1–54 through 1–57.

Lead Collision Vector

The shortest straight line course taken by a fighter aircraft toward a non-maneuvering bogey such that an air-launched weapon is pointed to collide with the bogey in space.

Conversion

The transition from a lead collision forward hemisphere approach to bogey to a beam-stern attack allowing sufficient room for maneuvering so as to maintain the bogey within the tracking limits of the radar during the final phase of the intercept.

Maneuvering Turn(s)

A turn or turns made by a fighter from a lead collision approach as necessary to effect a conversion. Maneuvering turns are usually called by the air controller.

Beam Stern Attack Gate

A position in space through which a fighter must pass to complete an attack turn (turn to bogey heading) without overshooting the bogey's flight path or permitting excessive bogey penetration toward the force.

Optimum Position

A check point after the maneuvering turn that will ensure passage through the beam-stern attack gate.

Attack Turn

The final pursuit turn to bogey heading in a beam-stern attack. It can be called by an air controller or controlled completely by the pilot. This turn always terminates in a pure pursuit tracking technique when using IR missiles without extended acquisition.

Pure Pursuit

A curvilinear course described by a fighter aircraft, normally in the horizontal plane, while closing a bogey. It is flown by maintaining the bogey at exactly 12 o'clock with respect to the fighter's nose. It can be flown visually or by centering the steering circle and dot in the radar track mode. See figure 1–55.

Lead Pursuit

A curvilinear course described by a fighter aircraft, normally in the horizontal plane, while closing a bogey. It is flown by maintaining a fixed or variable amount of lead ahead of the bogey. This can be flown visually by maintaining the fighter's nose ahead of the bogey or by maintaining the target or steering circle on the radar scope away from the direction of pursuit turn. See figure 1–56.

Acute Positions

Positions in space oriented ahead or inside the beam-stern attack gate such that if flown through the attack turn of the fighter will be restricted to pure pursuit techniques. An overshoot of the enemy's flight path may be expected.

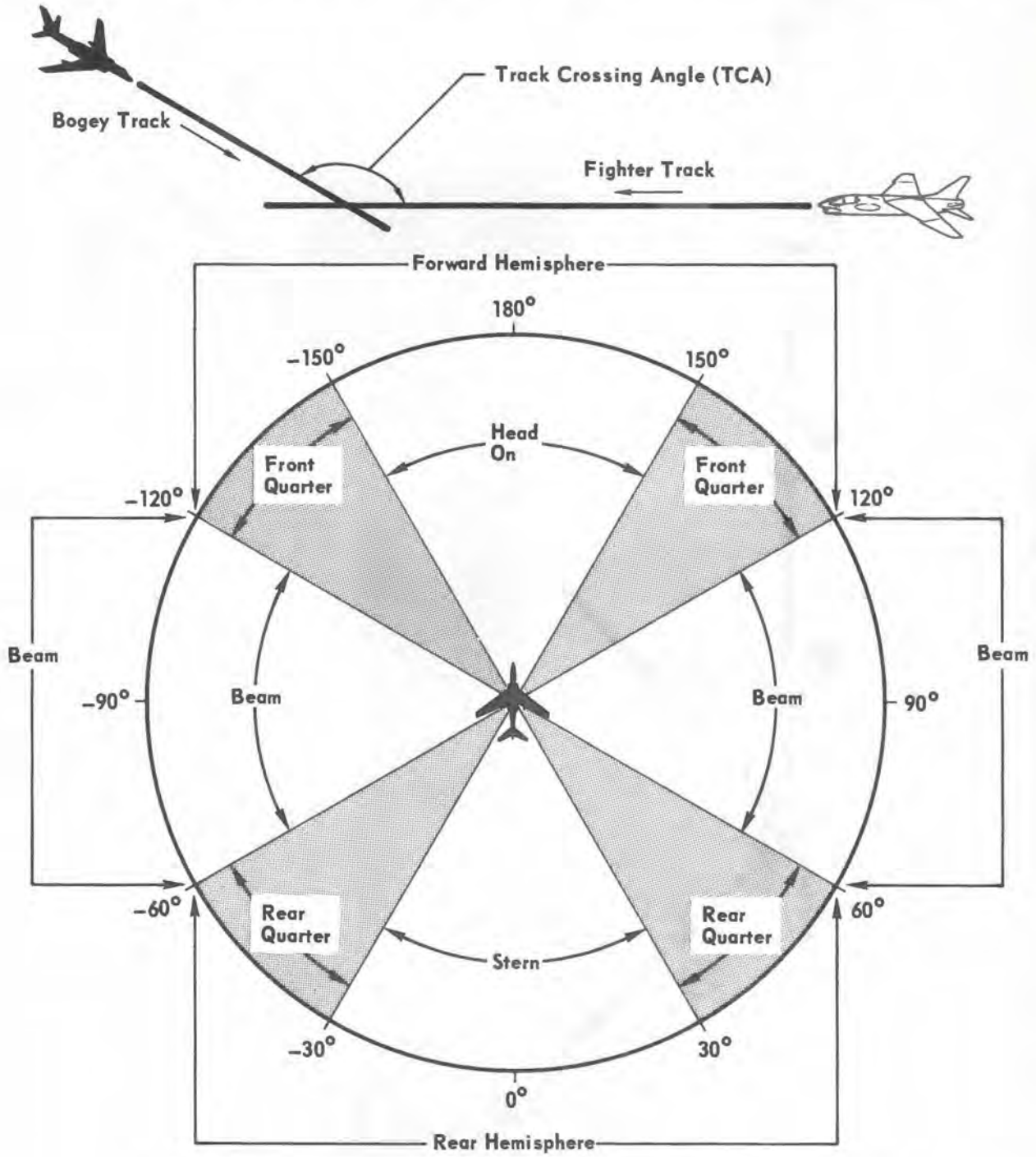
Sucked Positions

Positions in space oriented aft or outside of the beam-stern attack gate such that if flown through the attack turn of the fighter would require lead pursuit techniques and result in excessive bogey penetration toward the force.

BEAM-STERN TECHNIQUES

The classic 90-degree beam-stern intercept has many tactical advantages and disadvantages. In its favor, it presents the fighter with the largest radar target cross section. This is important in the case of a weak radar system. The closure rates associated with the beam approach are not excessive and allow relative ease in scope interpretation. The pilot can fly in either search or track mode as desired. The beam-stern attack is the only attack allowing the versatility of a multi-weapons launch. The disadvantages of the beam-stern attack are the bogey penetration toward the force, and the relatively late opportunity for detection caused by positioning the fighter with the necessary offset. Remember, the fighter radar might not come to bear on the bogey until after the maneuvering turn. With the fighter initially stationed between a raid that is coming toward the force, gaining the required offset usually causes fighter maneuvers that do not include illuminating the bogey until late in the intercept. If

Track Crossing Angles vs Fighter Approach



NOTE

Track crossing angles of less than 90° are referred to as "ANGLE OFF"

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Figure 1-53

Lead Collision Vectoring

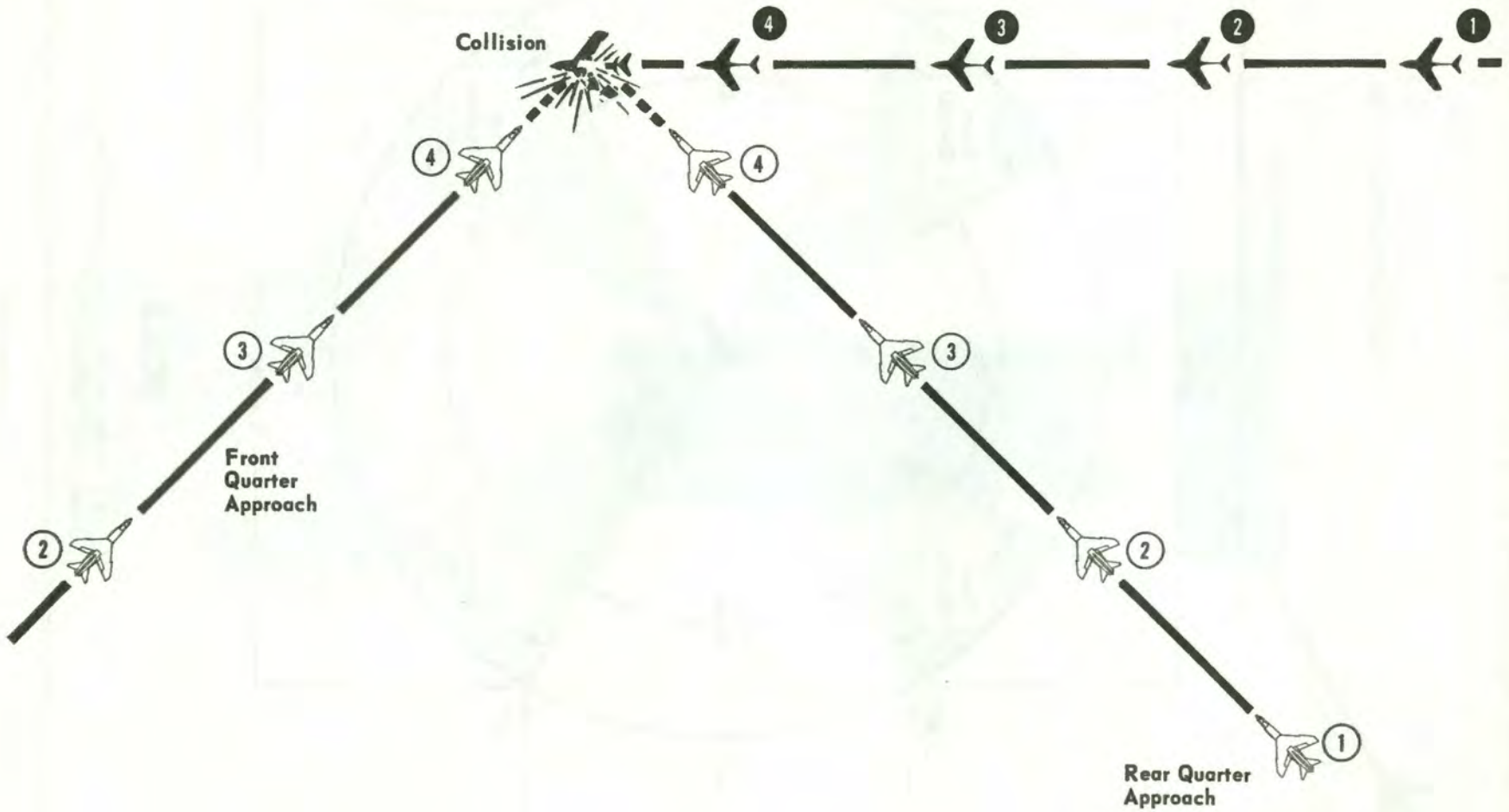
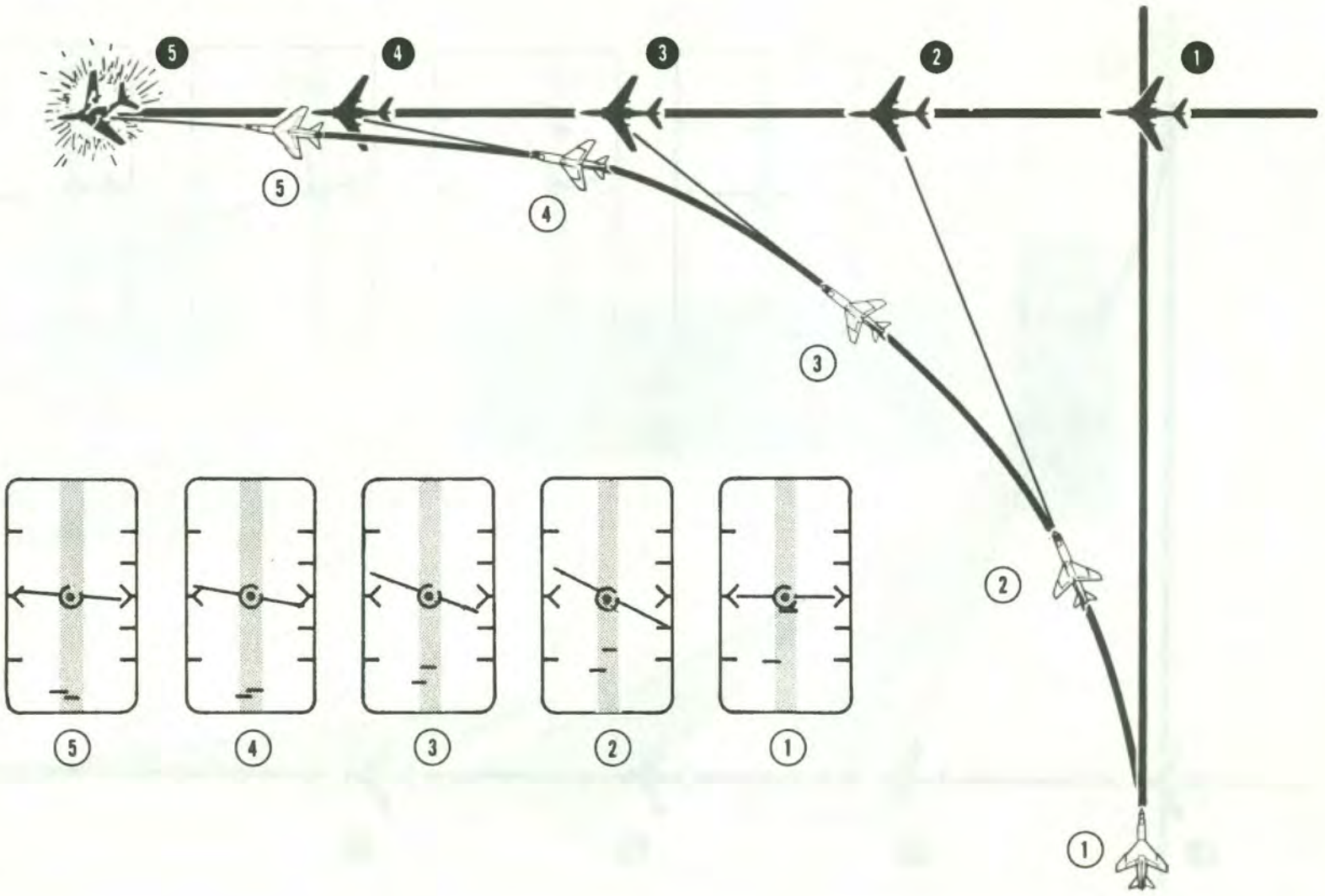


Figure 1-54

Pure Pursuit Attack Turn

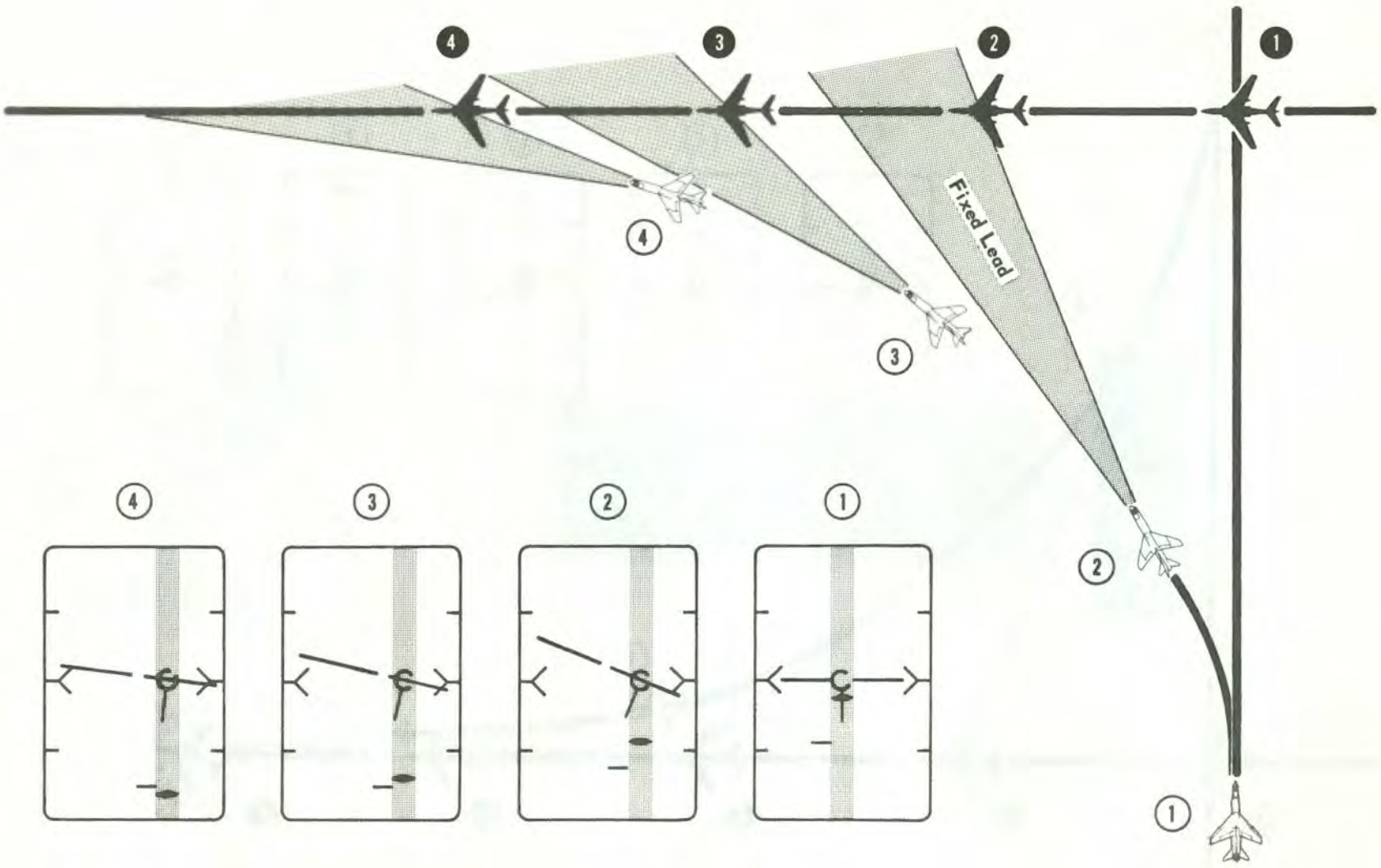
FIGHTER VS ENEMY SPEED RATIO 1.2:1



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Figure 1–55

Lead Pursuit Attack Turn



AZ–17–10–66

Figure 1–56

Lead Pursuit—Pure Pursuit Attack Turn

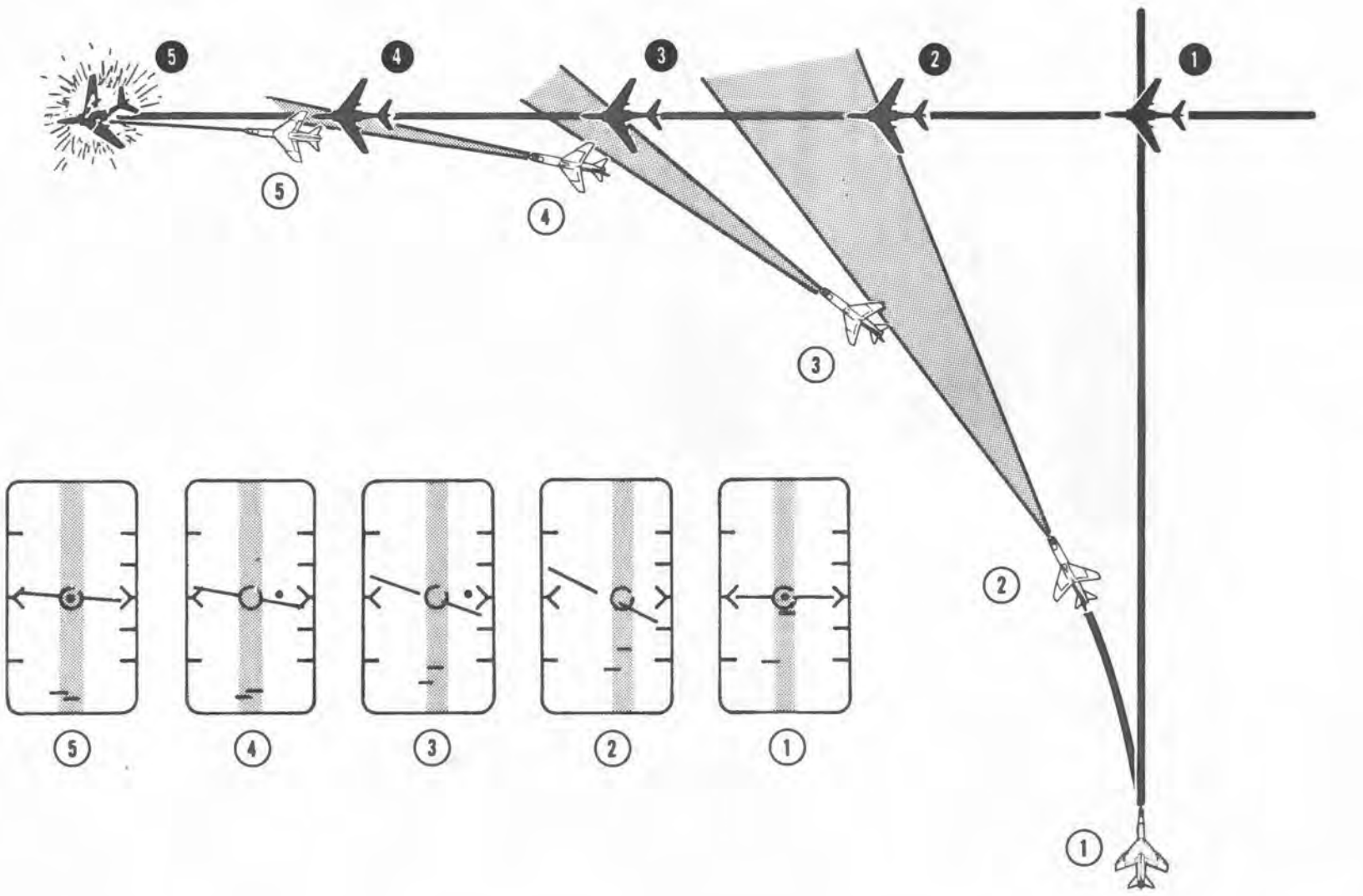


Figure 1–57

it is expected to intercept fighter-type aircraft, use of a beam-stern intercept is recommended. The tactical advantages of attacking from the stern far outweigh the disadvantages of this intercept.

Beam-Stern Attack Gate

The beam-stern attack gate as previously defined is similar to a low reversal window in a gunnery pattern; that is, it moves along in space with the bogey. To rigidly define this gate is very difficult as it varies with altitude, the fighter/bogey speed ratio, and, of course, individual pilot proficiency. A good beam-stern attack gate occurs at medium and high altitudes under the following conditions:

a. A 1.2:1 fighter to bogey speed ratio

b. 90 degrees of Attack Turn to go

c. The bogey directly ahead (12 o'clock ±10 degrees)

d. Seven-to-nine-mile range

The range is reduced to four to six miles at low altitude. Passage through this gate allows the attack turn to be made with relatively comfortable lead and pure-pursuit techniques and time for scope interpretation/geometry analysis. This is not to say that a pilot with a high level of radar experience cannot and should not strive to move this gate in to four or five miles at medium and high altitudes. Doing so requires a high rate of turn to bogey heading to maintain pure-pursuit tracking and acceptance of possible slight overshoots, with minimum time to devote to scope interpretation. This technique, however, has the advantage of arriving at a missile launch point with a minimum of bogey penetration. Consideration must be given to missile lethality, when it is expected that multi-expenditure of missiles will be necessary. Pressing the attack gate could cause the fighter to get too close to missile minimum range to permit damage assessment and a follow-up missile launch if required. Failure to consider this possibility could result in the necessity of a reattack which would allow excessive bogey penetration. Conversely, if guns are to be used, it is necessary to press the attack gate to arrive as close as possible for visual contact and maneuvering. Keep in mind the beam-stern attack gate depicted in figure 1–58 would not serve a gun attack as the fighter would have an excess of tail chase and maneuvering before entering gun firing range.

Beam-Stern Attack Turn

The attack turn is the maneuvering necessary to turn to bogey heading for a stern weapons launch. The technique required is directly dependent on the attack gate flown through. At medium and high altitude the procedure required for the attack turn is a combination of lead pursuit and pure pursuit tracking if the fighter passes through the recommended gate. The proper technique is to cause an initial rate of turn sufficient to create about 20 degrees of lead, holding this lead until approximately 45 degrees of turn to go and then gradually decreasing lead to zero (pure pursuit) arriving in trail on the bogey. The lead is reduced to zero as necessary to arrive at mid-range for the type of missile selected within 20 degrees angle off.

The corrections for acute positioning at the attack gate require pure pursuit tracking, and in some cases a hard and rapid turn away for a maximum of 30 degrees of turn followed by an immediate resumption of pure pursuit tracking to avoid overshooting. If the position at the attack gate is sucked, immediate lead pursuit techniques are required. The rate of turn is increased as necessary to establish up to 30 degrees of lead. In a 90-degree turning situation, it is extremely important to get the lead in and working during the initial part of the attack turn. After 45 degrees of turn, the lead becomes less effective and overtake speed is the primary factor working to close the target.

HEAD-ON INTERCEPT TECHNIQUES

The head-on intercept has the advantages of early opportunity to detect the bogey as the fighter's nose is pointed at the target throughout the intercept. Very high closure rates and minimum bogey penetration are associated with the head-on intercept. Also the fighter is exposed to a minimum of defensive armament if the bogey is a bomber. Disadvantages of head-on intercepts are: the minimum radar cross section of the target making detection difficult, especially with a weak radar system; considerable difficulty in acquiring the track mode with the sweeping range strobe; and only time enough to launch one AIM-9C missile without a reattack. Scope interpretation is fairly simple in spite of the very high closure rates, provided an early lock-on can be obtained. The procedure for an AIM-9C weapons launch is to steer as necessary for a pure pursuit approach to the target. The optimum position for AIM-9C launching is within 20 degrees of the bogey's nose.

The head-on intercept does not lend itself readily to a beam-stern conversion unless air controller called with sufficient bogey fighter separation for the offset maneuvering. The head-on intercept is not limited to the launch of AIM-9C missiles. An afterburning target might provide sufficient tones for launch of an AIM-9D missile. In aircraft equipped with the deviated pursuit computer, head-on fuzing of the AIM-9D is provided automatically at a closure rate of 1,100 fps. Additionally, it is necessary to be proficient at head-on tactics since bogey jinking could very well cause an intercept to result in a head-on situation in spite of fighter maneuvering. In this case, it is recommended to continue using pure pursuit techniques and execute a

Beam-Stern Attack Gate



1.2:1 FIGHTER SPEED ADVANTAGE

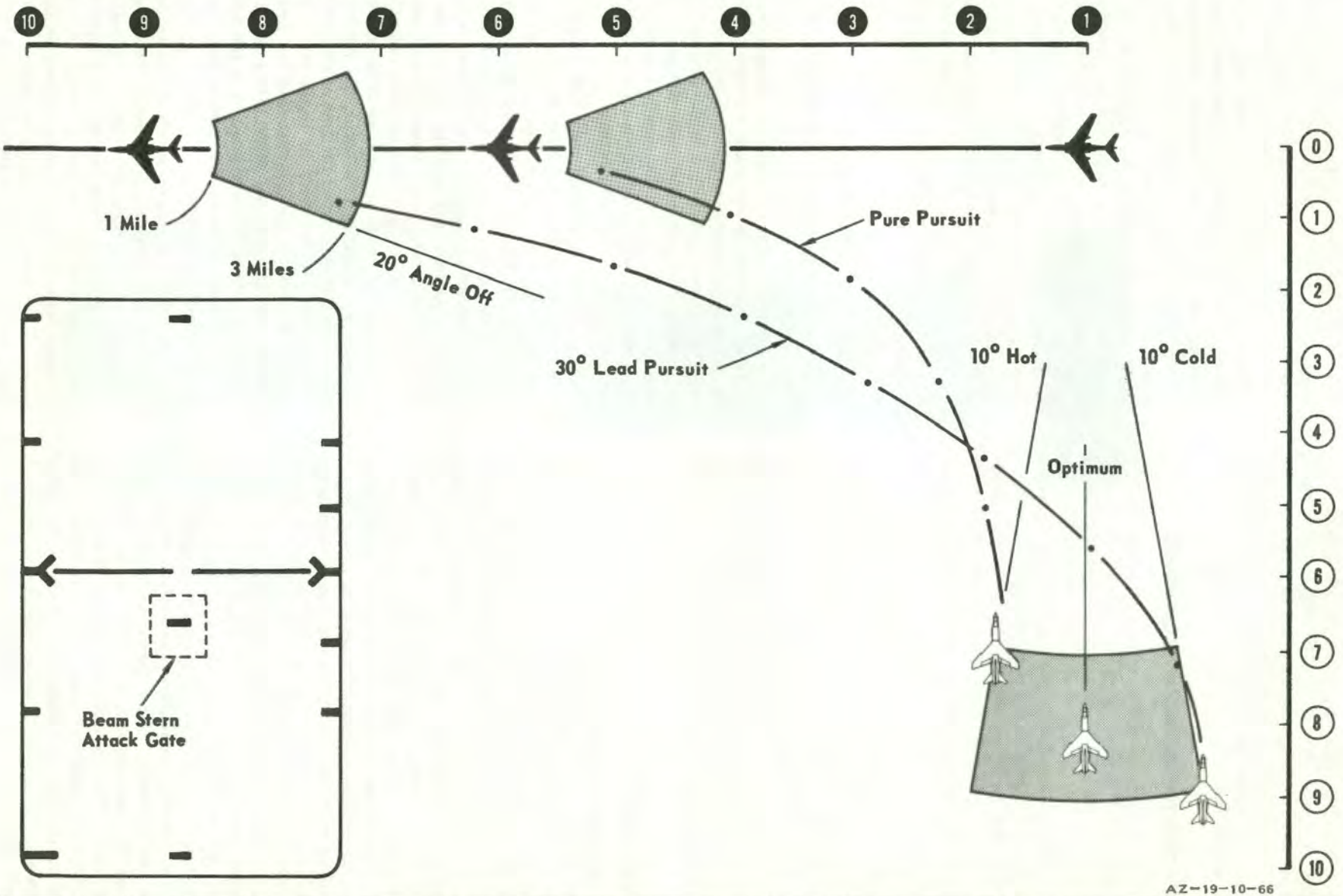


Figure 1–58

reattack into the bogey to enter the IR missile aerodynamic envelope. Due to the limited early warning potential and resulting unreliability of close air control at low altitude, it is recommended that head-on intercept tactics not be intentionally used at altitudes below 10,000 feet.

FRONT-QUARTER INTERCEPT TECHNIQUES

The front quarter intercept is a compromise of the advantages and disadvantages of the Head-On and Beam-Stern Intercept. A front quarter approach allows good target cross section for radar illumination (on all but the smallest fighter aircraft) and an excellent opportunity for detection since the fighter's nose is pointed at the bogey sooner in the intercept. Target penetration is relatively low. The closure rates, even subsonic, are high and require quick geometry analysis on the part of the pilot.

The front quarter is the most versatile intercept in that it affords an opportunity to employ a head-on weapon or allows for a conversion to a beam-stern intercept, and IR missile or guns employment. The track crossing angles combined with the high closure rates make the front quarter intercept the most difficult to interpret if a conversion is to be made. Early radar lock-on is recommended in the front quarter intercept to display the closure rate to the pilot and yield continuous information for rapid scope interpretation.

CONVERSIONS

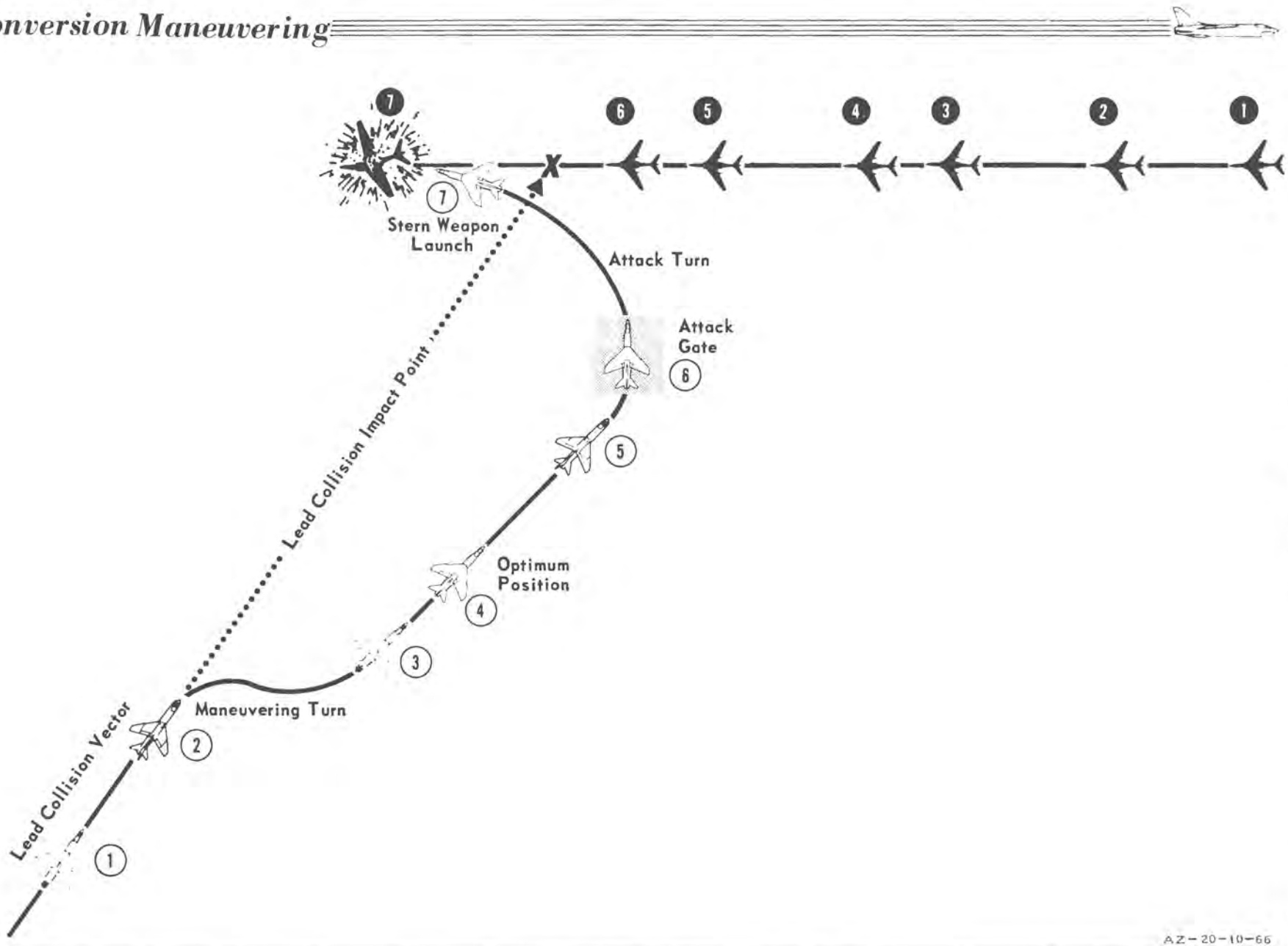
Successful conversions from a front quarter attack to a beam-stern attack can be made by the average fleet fighter pilot at track crossing angles up to 135 degrees. At greater track crossing angles, the ability to convert to a beam-stern attack becomes increasingly more difficult and depends on very early radar detection for the pilot, or expert air control. For a discussion of converting to a beam-stern attack from a head-on approach, refer to Part V, ECM/ECCM. The mechanics of effecting a pilot controlled conversion depends largely upon scope interpretation ability. Quick analysis of the radarscope data compared to known bogey and fighter headings (track crossing angles) are necessary to execute a "maneuvering turn" to get from the lead collision course directly to the bogey, to a lead collision course to the desired beam-stern attack gate. The maneuvering turn is an "S" type turn, initially toward the bogey's tail, then reversed back into the bogey (figure 1–59). The pilot who is extremely successful at effecting conversions knows how to find the attack gate he wants. Since the attack gate does not paint on the radarscope, it must be found by reference to the bogey. Each fighter pilot should have at hand some optimum position points, such as in figure 1–60, to aid in developing a seaman's eye ability to effect conversions. The easiest optimum position to deal with is when the bogey is directly ahead at a given range. Corrections for errors in the maneuvering turn are the same as any acute or sucked positioning. If the bogey is at 12 o'clock at greater than optimum position range, then the fighter is sucked and must correct into the bogey. This can be done by holding pure pursuit tracking or, if severely sucked, lead pursuit tracking until arriving at the optimum position. Conversely, when the fighter arrives at optimum position range and the bogey is on the cold side of the scope, then an immediate turn away (toward the bogey's tail) as much as 30 degrees is required, followed by a turn back into the bogey. Correcting for this acute siutation is the most difficult maneuver to handle in effecting successful conversions. Failure to sufficiently correct for acute conversion positioning requires accepting a reattack (or unavoidable overshoot which is in effect a reattack) and greater bogey penetration. Once the desired attack gate is reached, the remainder of the intercept techniques are as described in the beam-stern section. Illustrations of conversion geometry are presented in figures 1–61 and 1–62.

BREAKAWAY PROCEDURES

After an attack has been completed and a warhead has been detonated in the vicinity of the enemy target, there are a number of collision dangers existing for the fighter. First, in the event a target is still capable of proceeding along its original flight path, the fighter must avoid collision with a high velocity object. Second, when the target has been damaged and debris exists in the vicinity of the missile impact, the fighter must void the debris. Multiple targets further add to the problem of collision danger.

In establishing the danger zone that the fighter must avoid, various possibilities must be considered. If two missiles are launched, the target may be hit by the first missile, by the second missile, by both, or missed by both. If the target is hit, it may break up in a few large parts which continue along their initial trajectory with a speed only slightly reduced. On the other hand, it may break up in a cloud of small pieces which decelerates very rapidly, but expands radially. As it is not possible to know at the time of breakaway which of these eventualities will occur, the fighter must be maneuvered to stay out of the area of all possible lethal collision points. In order to break away safely, the fighter must avoid an area between the first possible missile impact point and the collision point with the undamaged target. Furthermore, it is not sufficient to avoid the line between these points, since debris may exist around the line.

The breakaway maneuver in the plane of the fighter is difficult because of the large area to be avoided. Such avoidance is made especially difficult by multiple missile launches, which cause the fighter to approach minimum missile launch range. A better answer to the problem lies in maneuvering perpendicular to the plane of intercept. This plane is defined by the target flight path vector and the fighter position. The danger



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Figure 1–59

Conversion Data

TRACK CROSSING ANGLE		110°	115°	120°	125°	130°	135°
OPTIMUM POSITION	BOGEY POSITION	12 O'clock	12 O'clock	12 O'clock	12 O'clock	12 O'clock	12 O'clock
	DISTANCE NAUTICAL MILES	10	12	14	16	18	20
Commence 60° Bank Turn To Pass Through 7-9 Mile Attack Gate			12 Miles	12 Miles	12 Miles	12 Miles	12 Miles

This table depicts optimum positions to ensure passage through the beam-stem attack gate with various TRACK CROSSING ANGLES. The thumb rule distances at which the bogey should be at 12 o'clock will result in passage through the 7-9 mile beam-stem attack gate. The TCA must be maintained until 12 miles, followed by a 60° BANK TURN until the attack gate is reached. From the attack gate "as necessary" attack turn techniques should be maintained until in position to fire.

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Figure 1–60

area perpendicular to the plane is that formed by the cross section of the debris pattern. In order to maximize the safety of the fighter during multiple missile launches, the breakaway maneuver should be performed in a direction perpendicular to the intercept plane.

Multiple targets pose an additional collision threat. It cannot be too strongly emphasized that there are no firm breakaway rules which will prevent a collision in all attack situations. Proper analysis of the tactical situation by the pilot and air controller will determine the specific procedure to be used.

In addition to avoiding a collision with the target or target debris, there are two other prime considerations that determine breakaway procedures. One is the necessity of clearing the target area so that a trailing fighter may complete an attack. The other consideration is the reassignment of the fighter after the initial attack. The fighter will be committed either to a reattack on the same raid, an attack on a new raid, vectored to a CAP station, or be returned to base.

Since the controlling agency knows the tactical situation, breakaway headings should be directed by the air controller. A breakaway heading which will cause the fighter to turn toward the direction of the flight path of the target is undesirable when employing in-trail tactics. The recommended in-trail separation will provide a marginal safety factor; however, controllers should commit fighters to these breakaway headings only when the tactical situation demands it.

REATTACK PROCEDURES

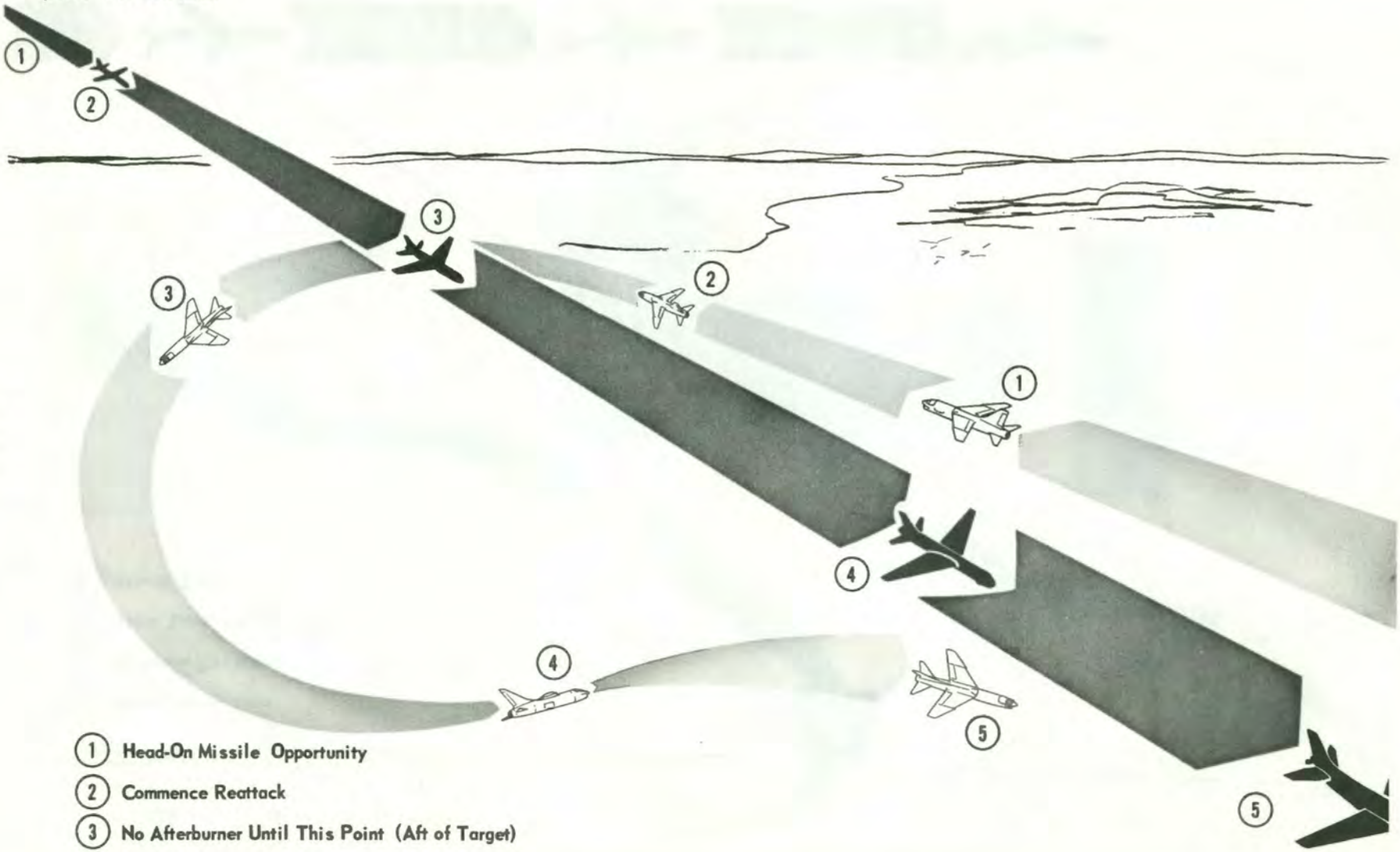
There are two basic reattack categories. They are the air controller controlled reattack and the pilot controlled reattack.

Air Controller Controlled Reattacks

After the initial attack, the air controller directs the fighter to a position to commence a new attack on the same raid. This type of reattack allows greater target penetration distance than a pilot controlled reattack. On the other hand, it is a more reliable and selective

Pilot Controlled Head-On Reattack

(NOT TO SCALE)



1. Head-On Missile Opportunity
2. Commence Reattack
3. No Afterburner Until This Point (Aft of Target)
4. Reacquisition of Target
5. Stern Missile Opportunity

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Figure 1-61

Front Quarter Beam Astern Conversion

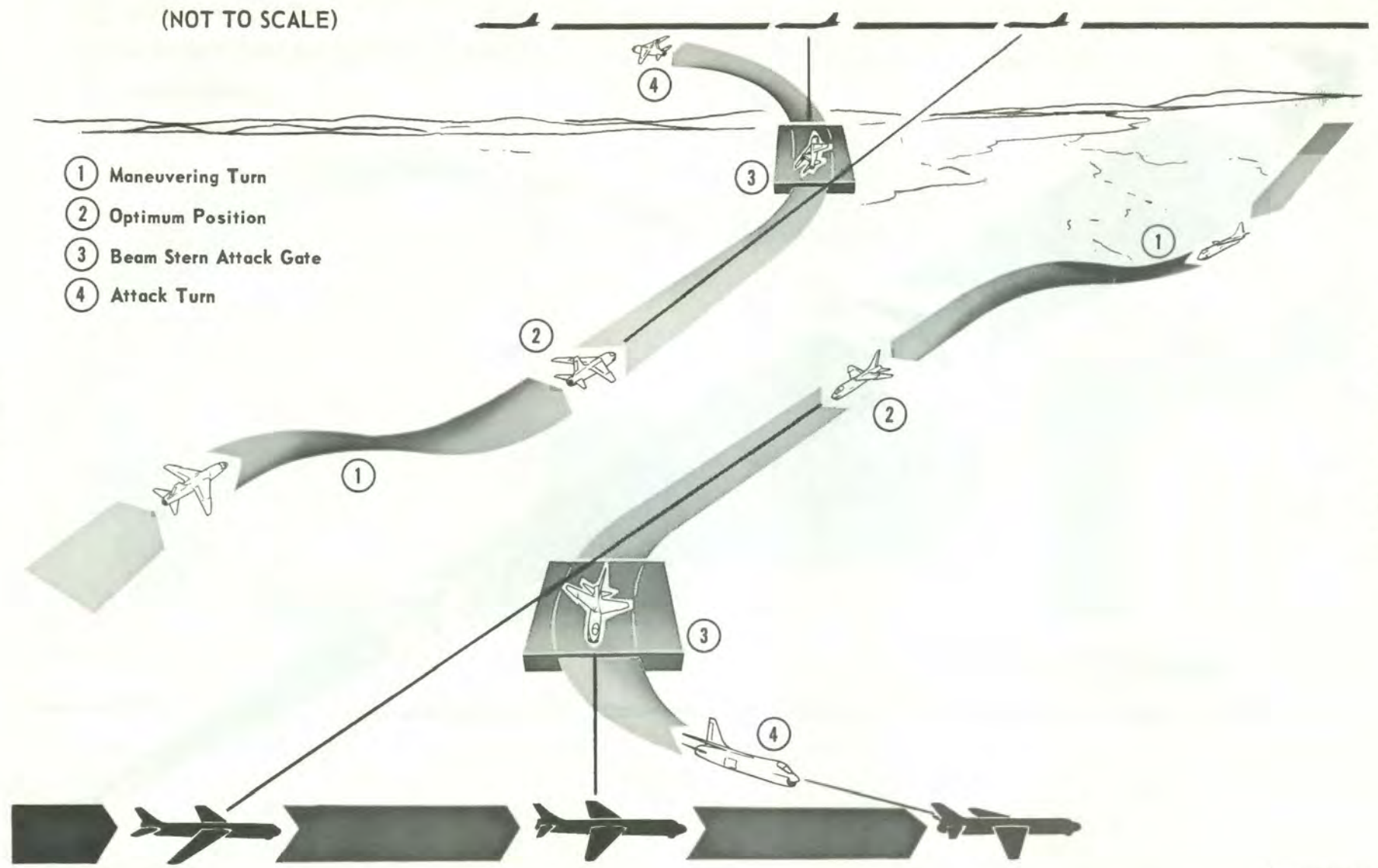


Figure 1-62

method. This method should be employed if enemy fighters are in the raid being attacked. Without air controller assistance, the fighter would be required to attack the fighters as a matter of self-preservation. With air controller assistance, high closing velocity reattacks against bombers could be made with a minimum of interference from the defending fighters.

Pilot Controlled Reattacks

The pilot controlled reattack is also a separate and distinct attack on the same raid. However, it is conducted by the pilot, using a pre-planned procedure and a knowledge of target heading, altitude, and airspeed. This type of attack has the advantage of minimizing target penetration between attacks. However, it has the disadvantage of being unreliable. Any pilot errors may be compounded by raid jinking or incorrect raid heading, altitude or airspeed information.

The pilot controlled reattack from a trail formation should not be attempted until either all fighters have launched missiles or until succeeding pilots have been given a "Hold Fire." All pilots must acknowledge this command.

Pilot controlled reattacks from a stern attack should not be confused with a continuing stern attack. During a continuing stern attack the fighter remains within missile range (but outside of enemy defensive armament range) and launches missiles until all aircraft in the raid are destroyed or all missiles are expended. A reattack, however, consists of a separate and distinct attack on the same raid. For the reattack from the stern, the fighter should turn in the direction of target origin until on a heading 60 degrees from the target's flight path. This heading should be held for 45 seconds and speed increased to a 1.2:1 ratio. At the end of 45 seconds, roll into 60 degrees of bank and turn 90 degrees toward the raid. Allow the nose to fall through the horizon as necessary to maintain speed and to reduce altitude to less than that of the raid. When target detection and lock-on have been achieved, speed may be increased to expedite the intercept. If target detection has not occurred at the completion of this turn, the pilot must continue the turn for an additional 30 degrees. If the target is still not detected, it will be necessary for the air controller to reposition the fighter for another attack.

Pilot controlled reattacks from an initial forward quarter or head-on attack should always be executed by a level turn into the bogey at 60 degrees angle of bank (significant turn). For a relative closure rate of 1.7 IMN the reattack should commence at six miles nose to nose. For each one-tenth increase in closing Mach above 1.7 IMN add one mile to the initial six miles to arrive at the correct distance to commence reattack. It is important to note that the reattack range is not associated with AIM-9C in-envelope range but is well inside it. Commencing a reattack at maximum AIM-9C range will cause the fighter to turn ahead of the bogey. Afterburner is necessary to sustain fighter Mach in part of the reattack turn; however, it should be used only after the fighter has turned beyond 90 degrees of heading with respect to the bogey to avoid detection. If the bogey speed is subsonic, the reattack turn should be continued for 40 degrees beyond the bogey's heading. Supersonic speed on the part of either the fighter or bogey calls for a turn of 50 degrees past the bogey's heading. Properly executed, the reattack should terminate with the fighter within AIM-9B maximum range; however, some target penetration must be allowed while the fighter positions within the allowable angle-off. At a relative closure rate of 1.7 IMN, the bogey will travel an average distance of 17 miles between the time an AIM-9C can be fired head-on and an AIM-9B or -9D can be fired from astern. Use of the vertical plane in a reattack turn will derogate the reattack with respect to time (bogey penetration) and is not recommended unless the bogey is observed to counter. A pictorial illustration of a pilot controlled head-on reattack is presented in figure 1–61.

MISSILES TO GUNS TRANSITION

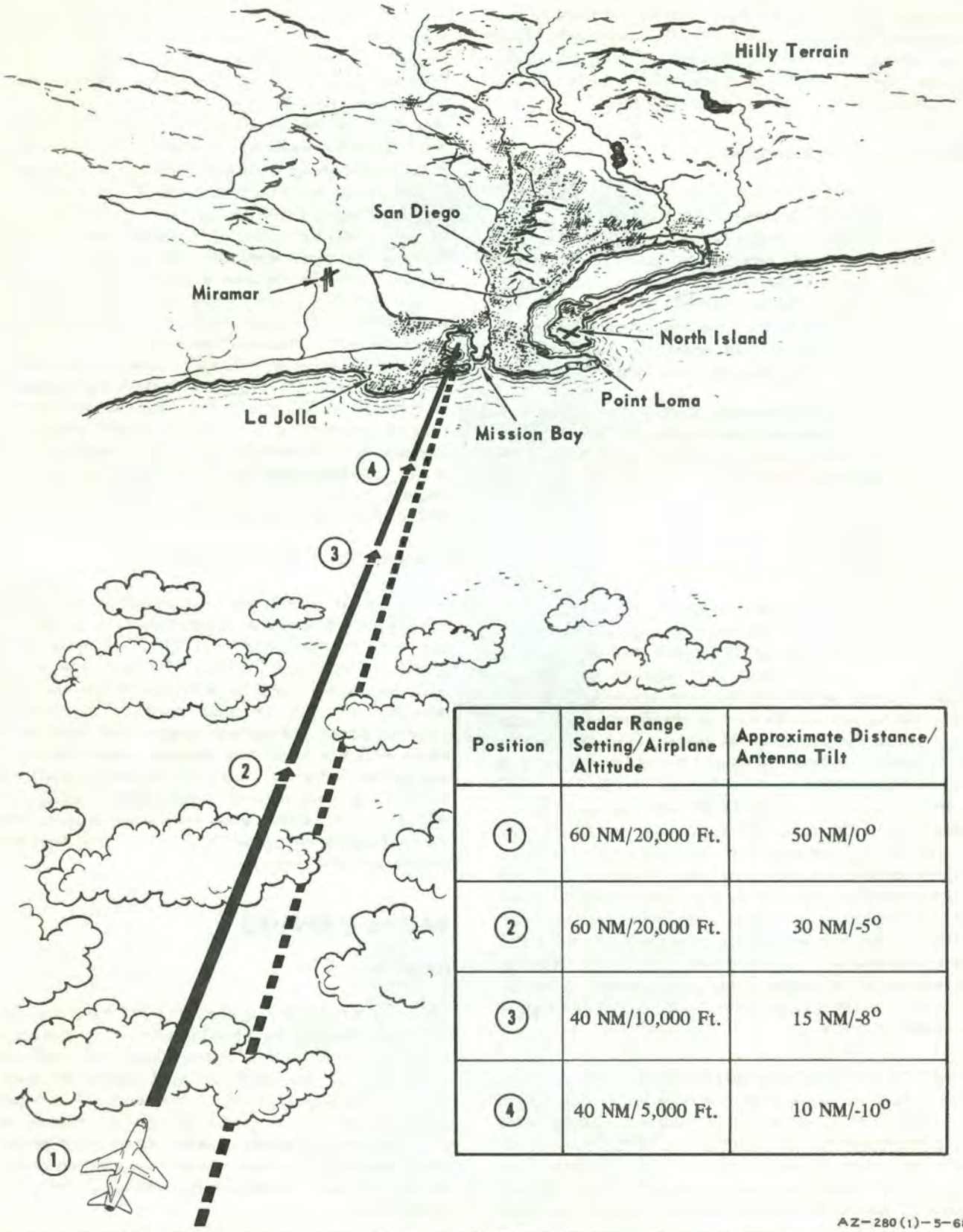
Whenever it is necessary or desirable to transition from a missile attack to a gun attack, it is only necessary with the APQ-83B or APQ-124 to move the gun selector switches full forward. This will cause hot guns with gun aural tones. If retention of missile tones is desirable, the gun switches must be in the middle position (guns hot–missile tones). Selection of BAT mode will not affect any existing radar lock-on, but sets up the radar for visual acquisition in case lock-on is lost and a subsequent engagement ensues. In the APS-67 system, either guns or missiles must be totally selected. Maintaining hot missiles and hot guns simultaneously is not possible.

RADAR MAPPING

GENERAL

Both the APQ-83B and the APQ-124 have a mapping capability suitable for identification of prominent geographical areas such as islands, bays, and peninsulas. Utilization of this capability will enable the pilot to navigate accurately without reference to navigation aids. The feature is useful in locating coastal entry and exit points at night or when an overcast precludes visual navigation. Areas of heavy weather and precipitation can also be seen and avoided if desired. See figure 1–63.

Radar Mapping



Position	Radar Range Setting/Airplane Altitude	Approximate Distance/ Antenna Tilt
1	60 NM/20,000 Ft.	50 NM/0°
2	60 NM/20,000 Ft.	30 NM/-5°
3	40 NM/10,000 Ft.	15 NM/-8°
4	40 NM/5,000 Ft.	10 NM/-10°

AZ-280(1)-5-68

Figure 1–63 (Sheet 1)

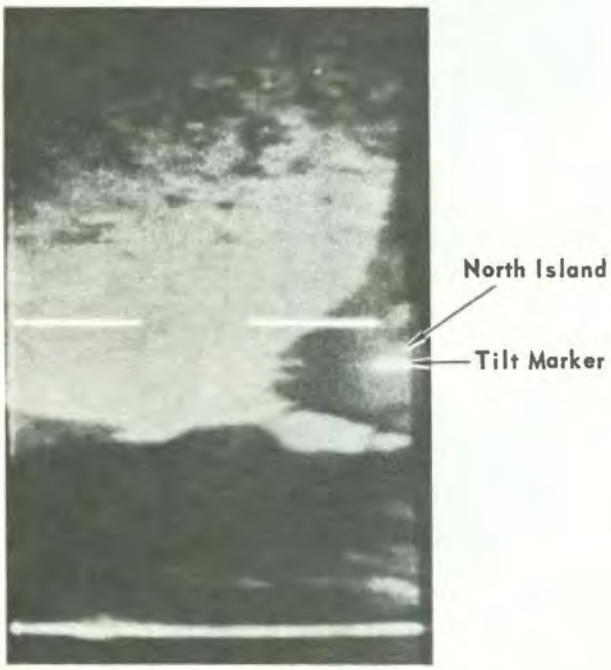
Radar Mapping



(1) Note clear coastal outline of La Jolla, Mission Bay, and Point Loma. North Island does not appear due to masking by the higher terrain of Point Loma. Foreground clutter is due to cloud and high sea state return.



(2) "B" scope distortion is becoming apparent in this photo and in photo 3, but the area is still identifiable. Foreground clutter is still present.



(3) North Island appears dimly in this photo. Note shadows caused by hilly terrain in background.



(4) Distortion is so great in this photo that scope interpretation is impossible.

AZ-280(2)-5-68

Figure 1-63 (Sheet 2)

MAPPING CHARACTERISTICS

When viewing an area at long range (upper third of the scope), the radar return displayed on the scope will closely approximate what a viewer would see on a chart. As the range decreases, distortion of the display occurs. In the lower third of the indicator the distortion becomes so great that area identification is virtually impossible. This is common to all B-scope displays. The pilot must keep in mind that the bottom of the B-display represents his entire aircraft, thus the area being mapped appears to expand as it gets closer.

Another phenomenon which appears on the scope is large blank areas on a solid land mass. These are radar shadows and are caused by blanking of radar energy by high land such as a mountain in the foreground. These can be useful in identifying an area especially when the high land is fairly isolated. The size and shape of the shadows is a direct function of aircraft altitude and antenna tilt setting. A shadow may not appear behind a large mountain if the altitude is high and the radar beam is pointing down steeply. It follows that radar shadowing will be maximum when at extremely low altitudes.

The narrow beam width of the radar in the vertical plane limits the area being illuminated by radar energy. This could cause confusion if the operator is not aware of the fact. When illuminating an area at 50 miles, an area at 20 miles may not appear on the scope at all. In general, mapping from high altitudes at short ranges results in the smallest area coverage, conversely mapping from low altitudes at long ranges yields the maximum area coverage.

MAPPING TECHNIQUES

As with all other radar operations, it takes practice to become proficient in radar mapping. From the foregoing paragraphs it becomes apparent that the major variables to be considered in mapping are range, altitude, antenna tilt and scope interpretation. Antenna tilt must be continually monitored to ensure illuminating the desired area and altitude changes should be considered. As the desired area approaches one-half scope range, selection of the next shortest range will minimize distortion. Scope clutter due to clouds or high sea state can make area identification difficult. In this case use of the FTC switch and varying intensity of B-bias may be useful. An area of heavy weather may be mistaken for a land mass; but by raising antenna tilt the operator can determine that the return remains, indicating that it has substantial height compared to a land target.

Since areas become unrecognizable as the range decreases, it is essential to be prepared to DR the last portion of the desired track. To do this requires a determination of ground speed and drift prior to losing mapping capability.

PART 5 — ECM/ECCM

INTRODUCTION

This section will utilize attack geometry as described in Part 4, Intercept Tactics. Countermeasures effects and counter-countermeasures procedures are precisely defined. The basic principles of intercept apply as outlined in Part 4. Part 5 is also a set of recipes from which to build an intercept. If there is any conflict in procedures between Part 4 and Part 5, it is due to the increased burden that a countermeasures environment imposes on the fighter aircraft.

PSYCHOLOGY OF OPPOSING ECM EQUIPPED TARGET

Problems of the Bomber

The fighter pilot has three advantages over a bomber target that employs countermeasures.

a. He is a shooter.

b. The bomber does not know how effective his countermeasures are during intercept.

c. The bomber does not know the exact range of the fighter. These problems serve as a great initial psychological boost for the fighter pilot. Fighter pilots should keep in mind that the bomber has the tasks of making an effective bomb run, and evading the fighter through the use of countermeasures; i.e., electronic, infrared, evasive maneuvering, or communications jamming or deception. The fighter's task is to arrive at a position to launch an air-to-air missile.

The bomber's countermeasures may not be equally effective throughout the intercept. He will usually secure electronic equipment periodically to search for other fighters on other frequencies and to determine any frequency change in the attacker's radar. He may also be forced to secure countermeasures equipment because it is interfering with equipment required for the bomb drop or air-to-surface missile launch. It is also possible that the fighter may fly through an area where the bomber antenna coverage is weak.

Bombers generally begin evasive maneuvering when continually illuminated by a fighter radar. The bomber is faced with finding a compromise between unlimited evasive maneuvering and a flight path which will allow accurate ordnance delivery. Since the bomber does not know exact fighter range, it may be forced to begin evasive maneuvering at ranges which do not complicate the geometry of the intercept for the fighter, but which further delay bomber progress toward the target.

Problems of the Fighter

A countermeasures environment is similar to air combat maneuvering in that the situation is continually changing. The bomber will attempt to use combinations of countermeasures during the intercept to discourage and distract the fighter pilot. Furthermore, the bomber may randomly sequence these countermeasures. The major tendency of the fighter pilot is to become mesmerized or fascinated by the strange scope display. This may cause him to accept a false lock or make him lose track of the bomber's position with the result that it slips by unharmed. To be able to follow the changing countermeasures and keep track of the bomber's position, the fighter pilot must have a complete knowledge of the functions and capabilities of his weapon system.

COUNTERMEASURES EFFECTS

The following paragraphs discuss the effects of chaff, noise jamming, range gate and angle deception, and evasive maneuvering countermeasures. These effects are subdivided into the effects on the radar search, acquisition, and track modes and Electronic Counter-Countermeasures Operating Procedures. For the purpose of this discussion, the acquisition mode is considered to be the period of manual control and the three-second period of "wide band tracking" which follows lighting of the T-lamp. The importance of this wide-band tracking phase will be brought out later. Track mode is considered as starting at the end of the three-second time period coincident with the appearance of V_c.

EFFECTS OF CHAFF ON THE APQ-83B/APQ-124

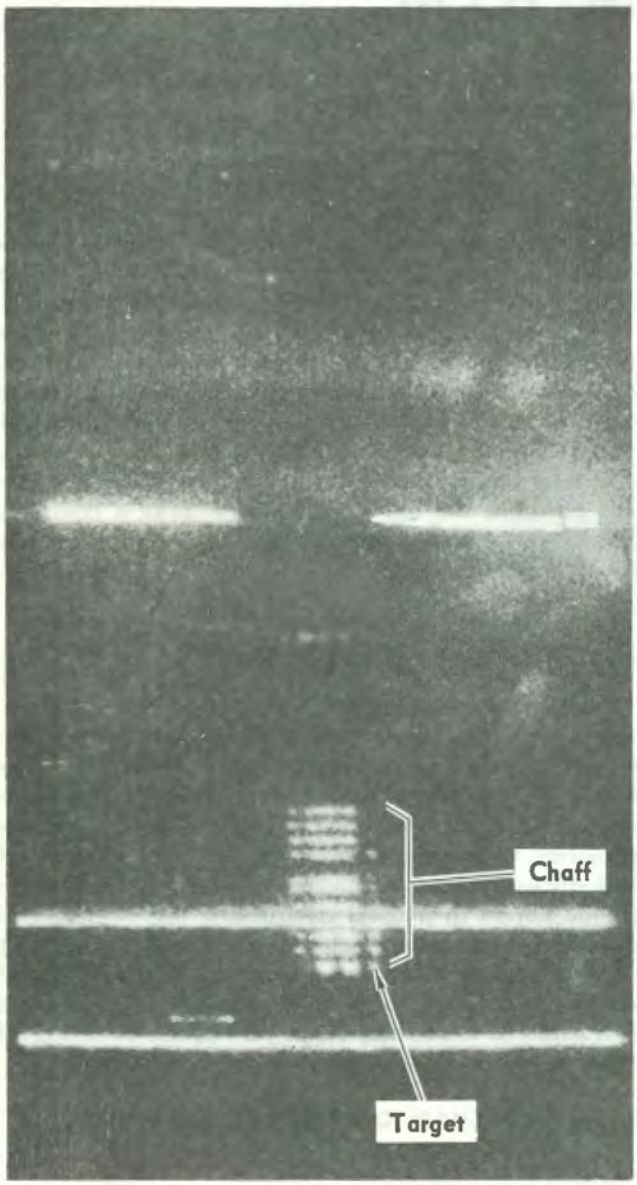
Search Mode

Chaff is employed to confuse the fighter pilot by presenting false targets on the radar scope. Chaff alone has little effect on the APQ-83B/APQ-124 in the search mode. Chaff may be dispensed from a target so that it appears as discrete bursts or as a continuous, uninterrupted stream (figure 1–64).

Chaff blossoms behind the target and appears wider in azimuth than the target. Chaff does not have the sharp definition of an aircraft target. Various chaff aspects are displayed in figure 1–65.

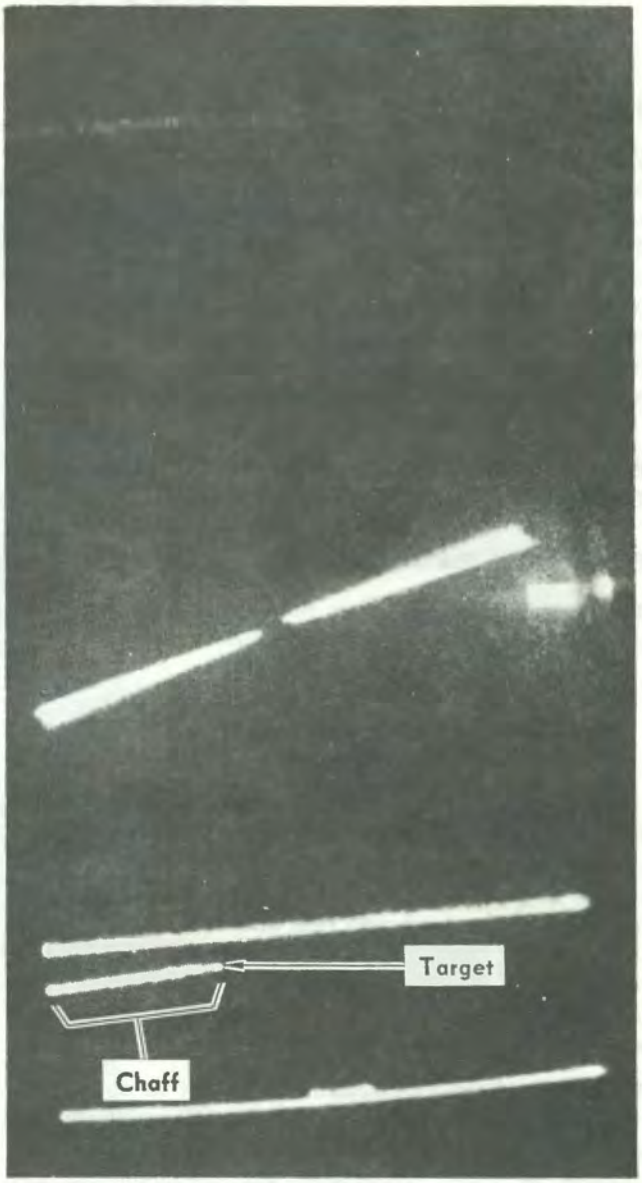
From the head-on or stern aspect, chaff appears as a vertical column behind the target. As the fighter departs from the above aspects, the chaff track will appear to slant sideways.

Chaff in the Search Mode



Discrete bundles of chaff

HEAD-ON ATTACK



Continuous uninterrupted chaff stream. The fighter has just passed through the attack gate and is making a pure pursuit attack turn with about 70 degrees to go to target heading.

AZ-122-11-66

Figure 1-64

Radar Scope Search Presentation

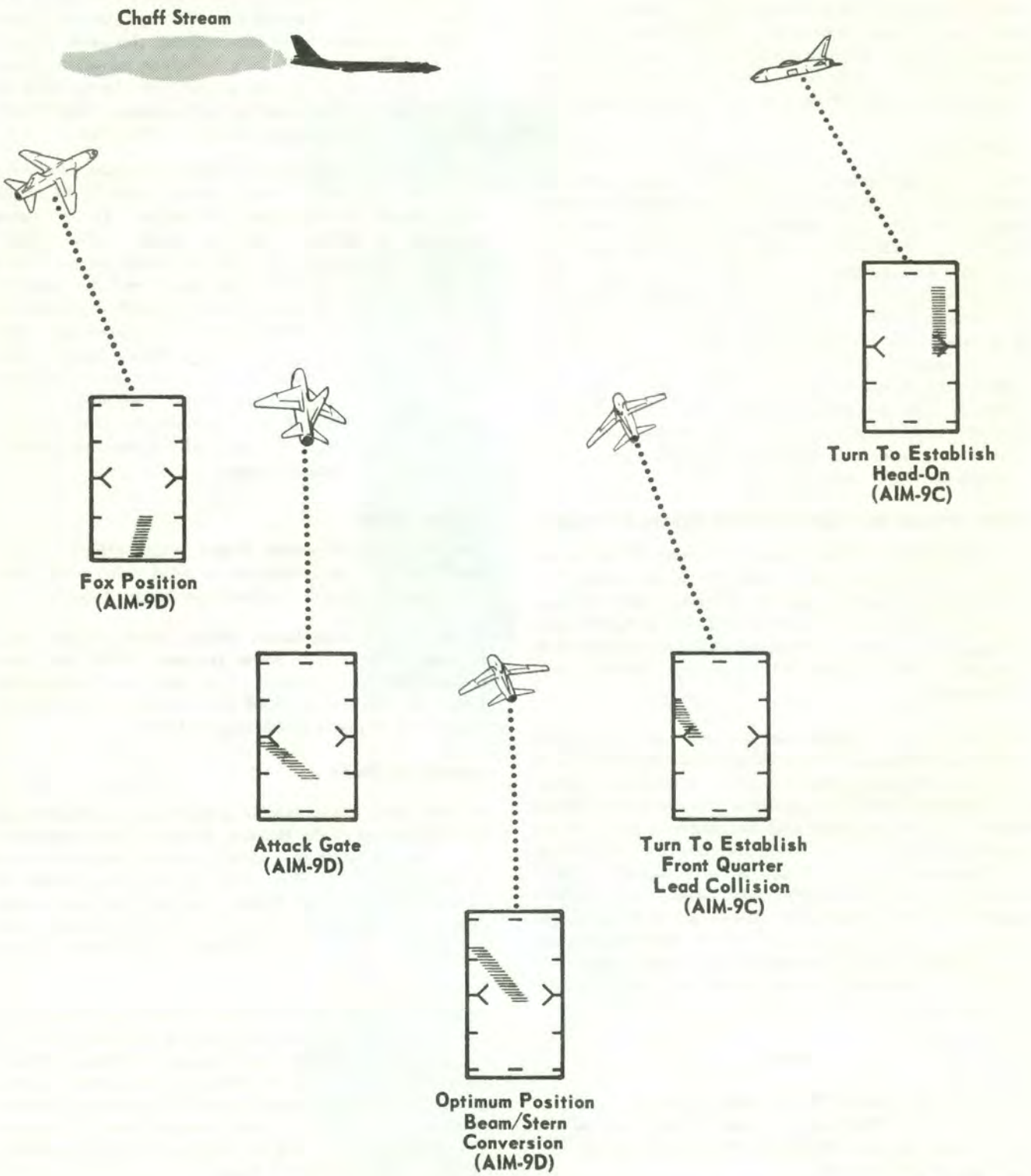


Figure 1–65

Acquisition Mode

Chaff looks much the same as in the search mode, except that illumination is limited to the chaff which lies within the azimuth of the B-trace. Chaff causes great difficulty in this mode because the range gate tends to lock on the strongest target within its 1,400-yard sweep. Acquisition is more difficult when the time interval between discrete bursts is decreased. When the target dispenses chaff in a continuous, uninterrupted stream, target acquisition generally is not possible.

Track Mode

When the fighter is in the head-on aspect, chaff has little effect on automatic tracking. As the fighter moves from head-on to the forward quarter aspect, the radar tends to transfer lock to chaff. In some instances, the pilot may successfully acquire and track a target from the stern aspect. Automatic track usually cannot be maintained in the beam aspect. A transfer of lock to chaff appears as a change of V_c when in the head-on or stern aspect. When head-on, the V_c decreases to fighter TAS. When in the stern aspect, the V_c increases to fighter TAS. In the beam aspect, the chaff and target have the same range rate, but drift of the dot and B-trace away from the direction of turn are reliable indications of a transfer to chaff.

ECCM OPERATING PROCEDURES AGAINST CHAFF

In a forward hemisphere lead collision attack an attempt to utilize the track mode should be made. The sweeping range gate should be placed so that it meets the target at the top of its outward sweep. Close monitoring of V_c must be maintained to detect lock-on shift to chaff. In APQ-124 the HOJ fixed range strobe should be utilized.

In a beam stern attack the full scan or sector scan search can be used. The recommended procedure is to use the spotlighting feature of the acquisition mode. Care must be taken to position the sweeping range strobe in a clear area beyond the target to preclude an undesired lock-on. This technique results in narrowing the illumination to the width of the collapsed B-trace. Careful manipulation of the radar hand control in azimuth will enable continuous illumination of the target and just a small portion of the chaff. Periodic returns to the search mode for at least four sweeps is desirable. Figure 1–65 depicts time sequenced chaff displays from various target aspects.

Note

DO NOT ACCEPT any radar lock-ons in a beam-stern chaff environment. Evaluation has proven that the APQ-83B will invariably shift lock-on to the chaff.

EFFECTS OF NOISE ON THE APQ-83B/APQ-124

The three basic operating modes of a noise jammer are spot, swept, and barrage. A spot jammer focuses its jamming power on a single frequency. A swept jammer is a spot noise jammer which is swept through a frequency band at a selected rate. Barrage jammers cover a wide frequency band, and appear the same as spot jammers. They usually lack sufficient power to be as effective in obscuring the target. For the purpose of this discussion, spot and barrage jammers will be considered to have the same effects on the radar.

For a jammer to obscure the target, it must produce a signal at the radar antenna strong enough to screen the reflected energy from the target. As the range decreases, a power cross-over point, called "burn-through," is reached. At this point the target return is stronger than the jamming signal and the target is visible through the noise. Burn-through can occur in all modes of radar operation. Useful ranges vary with the power output of the jammer. Noise jammers must be secured periodically to insure that the jammer is operating on the attacker's radar frequency and to detect the presence of new frequencies. This function may be accomplished automatically or manually and is called "jammer look-through."

Search Mode

Effective noise jamming denies target range and azimuth. Spot jamming appears as solid video which may cover part or all of the radar scope (figure 1–66).

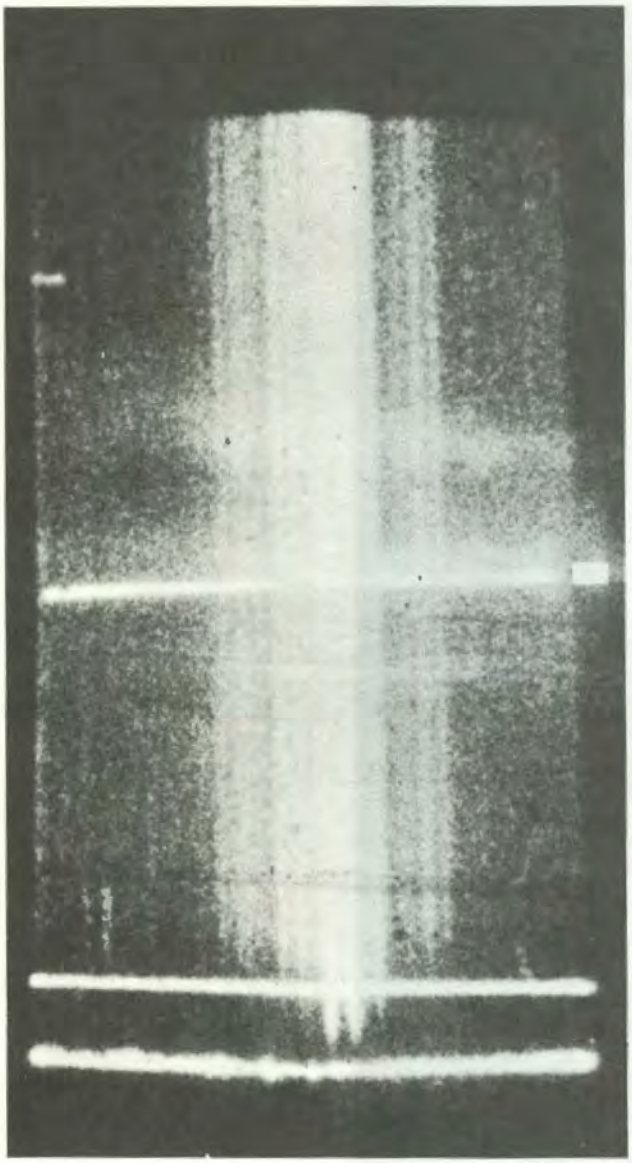
A series of vertical bands distinguishes a swept noise jammer from a spot noise jammer. When the pilot reduces the gain control, both spot and swept noise jamming will be reduced to a single vertical band, indicating target azimuth (figure 1–66).

Acquisition Mode

In this mode, noise jamming appears as a blossoming or brightening of the B-trace. Against a spot noise jammer, the APQ-83B will usually acquire an HOJ angle track immediately. The radar power switch must be in the HOJ position. When this happens, the J-lamp lights, the dot and steering circles are presented, and the B-trace shifts to the left side of the scope (figure 1–67).

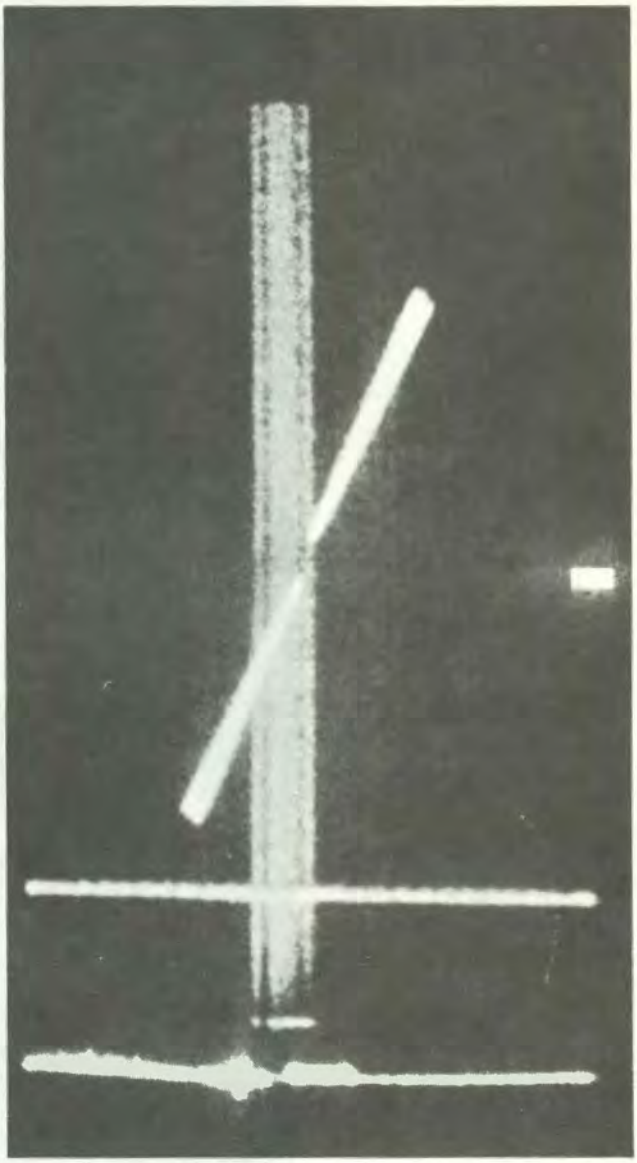
Against a swept noise jammer, HOJ angle tracks are rarely obtained because the jammer does not dwell on the fighter frequency long enough. Instead, a swept noise false lock-on is obtained which looks normal except for the blossoming B-trace. The range gate locks on the sweeping noise signal instead of the true target. The primary indication of this is a low or negative V_c (figure 1–68) in the track mode.

Spot Noise Jamming in Search Mode



Spot noise jamming against the fighter radar set at full gain.

FRONT QUARTER ATTACK



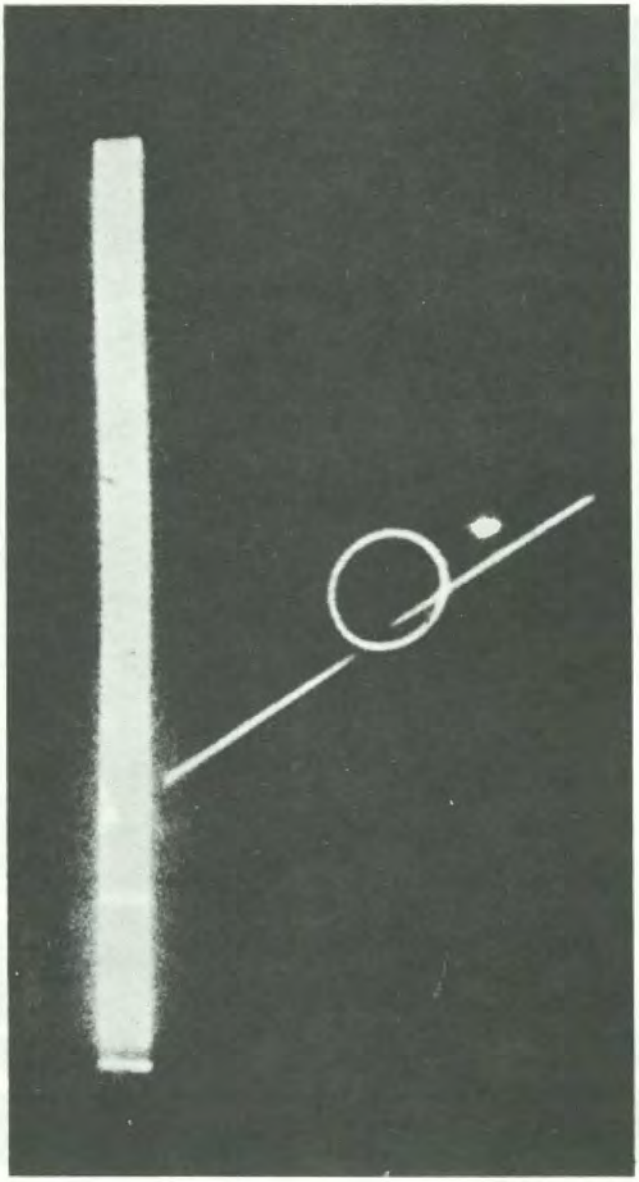
The fighter radar gain has been reduced to pinpoint target azimuth and to aid in exposing the hard jinking turns. The target has burned through at 2 miles.

STERN ATTACK

AZ-124-11-66

Figure 1–66

Typical HOJ Angle Track



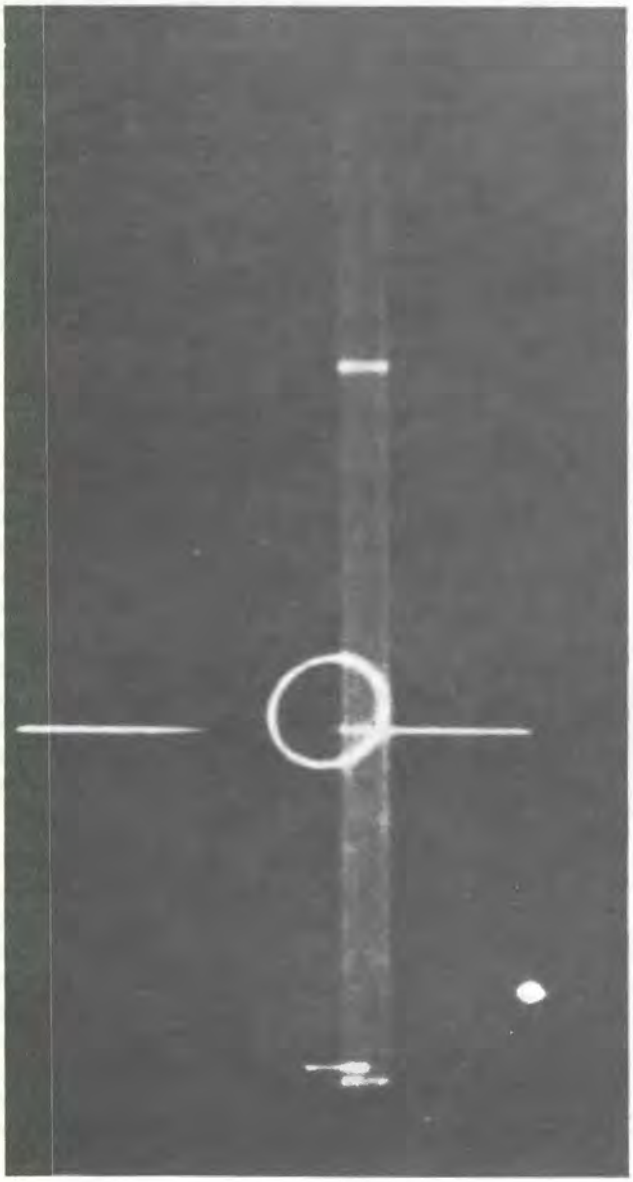
The fighter radar is tracking the target's noise jammer. Targets on the B-Trace are obscured by strong spot noise.

FRONT QUARTER ATTACK

AZ-125-11-66

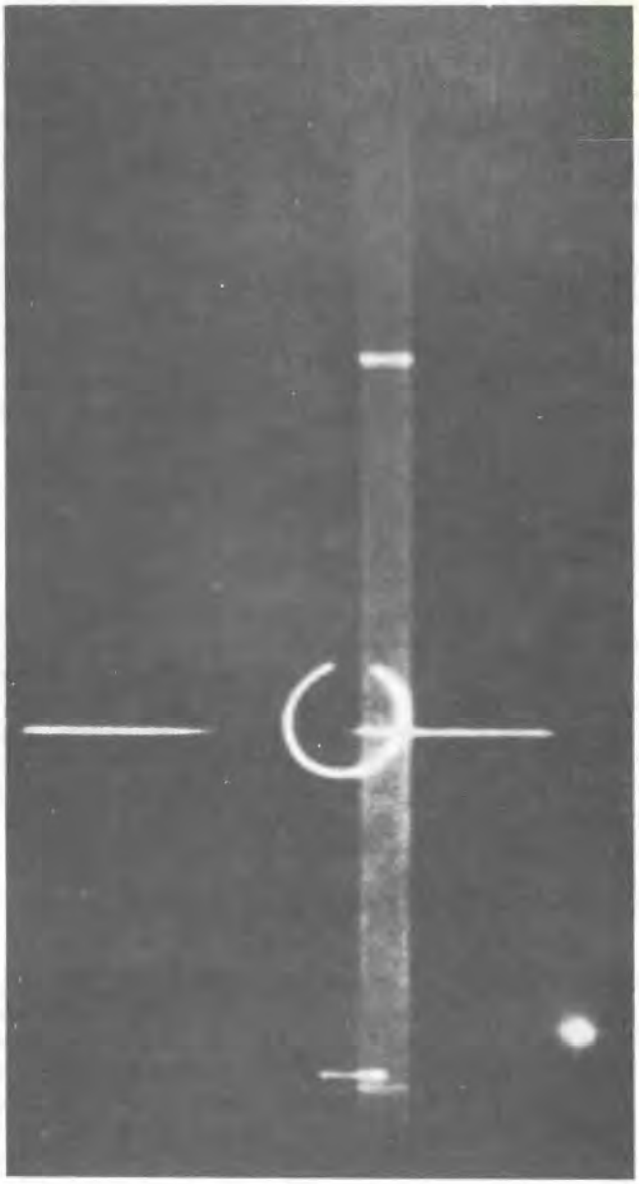
Figure 1–67

Swept Noise False Lock-On



Swept noise jamming commenced shortly after illumination of the "T" lamp in the three-second wideband tracking phase.

HEAD-ON ATTACK



V_c has appeared indicating the radar has commenced full track mode. The B-Trace is flashing with swept noise. The low or negative V_c is the key recognition feature of a swept noise false lock-on. The proper procedure is to break lock-on and reattempt track mode.

HEAD-ON ATTACK

AZ-126-11-66

Figure 1–68

Track Mode

In this mode as in the acquisition mode, noise jamming appears as a blossoming or brightening of the B-trace. Against a spot noise jammer, the APQ-83B will switch from an established automatic track to an HOJ angle track (if the radar power switch is in the HOJ position) provided the jamming is of sufficient strength and duration. Strong spot noise jamming will break a fully established automatic track causing the radar to return to search if the radar power switch is inadvertently left in the normal position. Range memory is provided during the initial six-second period after switching to an HOJ angle track and is indicated by continued illumination of the T-lamp. After the initial six-second period, the J-lamp remains illuminated and the radar tracks the noise signal in azimuth and elevation only. The radar will return to search upon loss of jammer signal for a period longer than three seconds.

Swept noise jammers do not disrupt fully established automatic tracks. Blinking of the B-trace will be noted, but shifts to HOJ angle track will not occur.

The APQ-124 might not shift into HOJ Pulse or HOJ PD even in the presence of intense noise jamming due to the dual magnetron operation. Since the radar set operates on two frequencies and most noise jammers utilize the listen-search detect-JAM principle, it is highly likely an enemy system would detect and jam one carrier frequency only. Retention of full system lock-on display is a tremendous advantage when the enemy thinks he is being most effective.

ECCM OPERATING PROCEDURES AGAINST NOISE

Check that the radar power or mode switch is in the HOJ position. In the presence of continuous spot noise the AIM-9C is the primary weapon. It may be launched from any aspect with an HOJ angle track. Against a spot sequential noise jammer (i.e., jamming on five seconds, jamming off five seconds, etc.), the AIM-9C is the primary weapon when making a forward hemisphere lead collision approach to the target. An AIM-9D is the primary missile if forced to make a beam-stern conversion. In the search mode, with either type of spot noise jamming, target azimuth can be pinpointed by reducing gain. Target elevation can be determined by adjusting the tilt marker so that the noise band appears at its brightest intensity. Attempt an HOJ angle track. The acquisition bar should be placed in the noise band before depressing the acquisition switch. Range is not available in the HOJ tracking mode, and must be estimated for missile launch. Target altitude can be determined with an HOJ angle track by adjusting fighter altitude until the steering information is centered in elevation. One method of angle ranging with an HOJ angle track from the head-on aspect at medium altitude is to position the fighter 5,000 feet below the target. When the dot reaches the upper 1-inch mark (9 degrees up), center the dot in the steering circle and attempt AIM-9C missile launch. The range at this time is 5.25 miles. Presence of a swept noise jammer may not be discovered until a lock-on is attempted in what appears to be a clear environment. If a lock-on attempt results in a swept noise false lock-on (figure 1–68), immediately break lock and reattempt lock-on. After three swept noise false lock-ons, complete a beam-stern conversion attack utilizing radar search mode and an AIM-9D missile as the primary missile.

EFFECTS OF DECEPTION ON THE APQ-83B/APQ-124

A range gate deceiver senses continuous radar illumination (which indicates fighter radar lock-on), and transmits a pulse at the same time that energy is reflected from the target. Each succeeding pulse is delayed, producing a false target which is stronger than the true target. It tends to "steal" the range gate and causes it to move off the true target in range. After four or five seconds of deceiver operation, the range gate has been moved so far from the true target that the target is no longer within the tracking gate. At this time the deceiver is usually secured and the fighter radar will return to search after six seconds of range memory.

An angle deceiver analyzes the conical scan rate of the fighter radar. A transponder generates an electronic pulse to produce a false target which is stronger than the reflected energy. The electronic phase of the false target is shifted 180 degrees from the true target. The effect is that the radar will track the stronger false target signal in angle and the antenna will move off the true target. When the jammer is secured, the true target is not within the beam width of the fighter radar and the radar returns to search after six seconds of range memory.

Search Mode

Range and angle deception jammers have no effect on the APQ-83B/APQ-124 in the search mode.

Acquisition Mode

In the manual control portion of this mode, range and angle deception jammers have no adverse effect. In the three-second period of wide band tracking prior to full stable track, the system is susceptible to angle and range gate deception. The fighter radar will not break

lock-on during this period. Since most deceivers employ a cycle time which exceeds the three-second time period, the radar will break lock-on and return to search from the track mode after six seconds of range memory.

Track Mode

The APQ-83B/APQ-124 is susceptible to range rate and angle deception which causes the radar to return to search as described above.

ECCM OPERATING PROCEDURES AGAINST DECEPTION

Angle deception can be recognized by relating the rate of dot movement of the radar scope to the target range and determine if this rate of movement is beyond the maneuvering capabilities of the target, or by breaking lock and re-acquiring the target in search, then noting changes in the target elevation or azimuth. For example, the target appears at 20 miles as the pilot locks on. The steering dot indicates the target is level. Almost immediately after lock-on the dot starts a downward drift and reaches the lower 1-inch mark (9 degrees down) in about 10 seconds. Since one degree of dot movement equals 2,000 feet at 20 miles, the rate of dot movement is 18,000 feet in 10 seconds. The target is not capable of this rate of change and the pilot suspects that angle deception is driving the antenna off the target in elevation. Similar dot movement to the left or right indicates that the deceiver is driving the antenna off in azimuth. The pilot should then break lock and observe the target position in azimuth and elevation. At closer ranges the only method of confirming angle deception is to break lock and observe the target position in the search mode. Angle deception at short range is very similar in appearance to target "jinking" in heading and altitude. In the track mode, the radar is susceptible to range gate deception which causes the radar to return to search after six seconds of range memory, but is designed to resist a change in V_c caused by a range gate stealer. For example, the range tracking gate will resist gate deception that attempts a rapid pull-off. Gate deception is recognized when the true target splits from the range gate, the calibrated vertical fluctuates in length, and the V_c shifts to the closing rate of the gate deceiver false target. Since the calibrated vertical is a function of range rate, it will fluctuate in length whenever a range gate stealer introduces a false variable range rate. When the fighter is vectored for a forward hemisphere lead collision approach, the AIM-9C is the primary weapon. Break lock-on immediately if either angle or range gate deception is suspected and immediately reattempt lock-on. If the deceiver successfully operates against the fighter radar after three lock-on attempts, a beam-stern conversion should be made utilizing the AIM-9D as the primary weapon.

EFFECTS OF EVASIVE MANEUVERING

Evasive maneuvers are changes in heading and altitude which are used by the target to complicate the intercept problem. Targets generally begin evasive maneuvers when illuminated by the fighter radar beam. The most common pattern is the S-turn. Subsonic targets at medium altitudes may change headings as much as 45 degrees either side of track and altitude as much as 5,000 feet. Supersonic targets at very high altitudes may change headings as much as 20 degrees either side of track, but altitude changes may be slight.

Search Mode

With accurate Air Intercept Control (AIC) inputs, evasive maneuvering does not present serious problems in this mode. In the absence of AIC assistance, the pilot will experience varying difficulty in determining flight maneuvers in relationship to the magnitude of the target movements and decreasing range.

Acquisition Mode

Evasive maneuvering causes serious problems in the acquisition mode, particularly at short ranges. The changing geometry of the intercept forces the pilot to split his attention between maneuvering the fighter and obtaining lock-on. The sweeping range gate contributes to the problem.

Track Mode

Evasive maneuvering does not present a problem in this mode.

ECCM OPERATING PROCEDURES AGAINST MANEUVERING TARGETS

Throughout the intercept, the pilot should vary the tilt marker so that in the search mode the target appears at equal intensity on both sweeps of the two-bar scan. Changes of target intensity on either sweep indicates changes in target altitude. Target fade on the upper sweep indicates the target is diving and target fade on the lower sweep indicates the target is climbing. This can be confirmed by readjusting the tilt marker. Attempt lock-on with wings straight and level. Lock-on attempts, while turning, may be necessary in order to stay within the AIM-9C envelope during final

stages of a level collision approach from the forward hemisphere. Lock-on attempts inside 10 miles range are not necessary if the fighter is turning to convert to a beam-stern attack because the AIM-9D is the primary weapon.

A target that is detected at 35 miles may reverse heading three or four times prior to the fighter reaching the AIM-9C envelope during a forward hemisphere lead collision approach. The lead launch computer should not be utilized until after the range has closed to 10 miles and then only during a front quarter lead collision attack with an AIM-9C. If lead launch is utilized at greater ranges, target jinking may result in improper lead sensing and the pilot may forget to deselect lead launch.

It is not necessary to utilize lead launch if the fighter is close to the head-on aspect; however, a jinking turn can immediately place the fighter in front quarter aspect as the target approaches R_{max} (maximum computed aerodynamic range).

The following procedures apply:

a. Place lead launch switch in the centered down position.

b. Center the dot inside the steering circle.

c. Attempt AIM-9C missile launch when "in envelope" with a continuous solid tone.

EFFECTS OF COMBINED ECM AND EVASIVE MANEUVERING

ECM and evasive maneuvering may be combined to complicate the intercept problem. The following combinations of countermeasures may be expected:

Type A — Chaff, noise, and evasive maneuvering.

Type B — Chaff, deception, and evasive maneuvering.

Simultaneous operation of noise and deception equipment is not a threat because each interferes with the operation of the other. However, the target may switch randomly from one to the other during an intercept.

Search Mode

Type A — When the target is operating with chaff and noise simultaneously, the noise obliterates the scope, completely hiding the chaff and the target. When gain is reduced, target azimuth can be pin-pointed. Generally, the target and chaff do not burn through until at very close ranges. The target may combine random programming of the chaff, noise, and evasive maneuvering. The target may secure chaff and noise while making a climbing or diving turn. The purpose of this technique is to leave a chaff track in hopes the fighter will chase the chaff and not see the target break out in its jinking maneuvers. This may place the fighter out of position and result in a prolonged tail-chase or require additional search time. In the absence of accurate AIC information, this bomber technique is effective in causing missed intercepts.

Type B — Deception does not affect the radar in the search mode. Chaff and evasive maneuvering produce the same effect as described above except that the target and chaff track can be more easily followed when the scope is not obliterated by noise.

Acquisition Mode

Type A — The effects vary with the type of noise jamming. When manually spotlighting a target which is using swept noise jamming, the target and chaff can be seen. If the target is using a spot noise jammer, the target and chaff will not be apparent until burn-through. Spot noise jamming will completely saturate the scope and preclude the use of the radar acquisition mode since the radar will immediately shift to HOJ angle track when the action switch is depressed. The radar power switch must be in the HOJ position. The acquisition problems encountered in single chaff, noise, or evasive maneuvering environments are compounded significantly.

Type B — Since deception equipment does not affect the radar prior to the three-second wide band tracking phase, the problem is similar to a chaff environment combined with evasive maneuvering.

Track Mode

A primary goal of countermeasures is to break the fighter radar lock. At any time track mode is established, the target may employ the following:

a. Spot noise (intended to put fighter radar into HOJ), followed by securing the jammer for a long enough period that the radar returns to search.

b. Range gate and/or angle deception to cause loss of track on target.

c. A turn to place the fighter near the beam aspect, followed by chaff drops to cause lock transfer.

If the fighter is inside 10 miles on a forward hemisphere lead collision attack, successful combined countermeasures result in loss of track on the true target

with little change for regaining lock-on. This will commit the fighter to a beam-stern conversion which generally results in a prolonged tail-chase.

ECCM OPERATING PROCEDURES AGAINST COMBINED ELECTRONIC COUNTERMEASURES AND EVASIVE MANEUVERING

The following techniques reflect intercept procedures for a single fighter under close control against a single bomber. In this case, the fighter is defending the force on CAP station and receives a lead-collision vector. The fighter attempts to make a forward hemisphere attack on the bomber utilizing an AIM-9C missile.

Detection should be attempted as soon as the initial vector heading is reached. When at the desired attack altitude, autopilot and altitude-hold should be engaged. The target may begin evasive maneuvering and chaff drops if momentarily "manually spotlighted." Keeping the target at equal intensity on both sweeps of the search mode by varying the tilt marker indicates that the center of the radar beam is on target. Attempting to lock-on at maximum possible range (25 miles) affords the greatest opportunity to analyze the effects of target countermeasures against the acquisition and track modes. Repeated lock-on attempts may result in false locks on swept noise or chaff. These lock-ons should be broken immediately by the pilot. Automatic track may be broken by the random on/off programming of a spot noise jammer or by range and angle deception. The pilot should immediately return to the search mode if the J-lamp goes out during HOJ angle track or when the radar begins to succumb to range gate or angle deception. The decision to remain in the search mode and commence a beam-stern conversion should be made between 10–15 miles if difficulty is experienced with electronic countermeasures. Though the radar is not affected by deception in the search mode, the pilot may have difficulty in illuminating a jinking target that is randomly sequencing a spot noise jammer and chaff drops. Strong spot noise obliterates the scope but target azimuth and elevation can be pinpointed by reducing gain and varying the tilt marker. Chaff presents a problem if the pilot does not see the target break out of the chaff track in its jinking maneuver. Momentary spot noise may further cover-up the jinking maneuver. Evasive maneuvering presents a problem if the pilot loses communication with the AIC. When it becomes apparent that a beam-stern conversion is necessary and the target is obscured by countermeasures in the search mode (spot noise and chaff), a pure pursuit attack is flown while attempting a visual tally-ho utilizing the AIM-9D as the primary weapon.

Using radar search mode, keep the noise band or leading edge of the chaff track on the nose during the beam-stern conversion until tally-ho. When directly head-on, a conversion to a beam-stern attack can be made by making a hard (maneuvering) turn at 10 miles to place the target on the edge of the scope, then reversing into a hard turn at seven miles (optimum position) to drift the target to the nose. This should place a medium altitude subsonic target on the nose at three miles, with 90 degrees to go to target heading.

Note

The HOJ power position should be utilized in all types of ECM environments.

ECM EFFECTS AND ECCM PROCEDURES FOR THE APS-67

Chaff

Chaff effects the APS-67 in much the same way as the APQ-83B/-124. The search mode is the only usable mode. Due to the 2 mile sweeping range stroke, any attempt to lock-on in a chaff environment would probably result in a shift lock to chaff. Using manual tuning may appear to diminish the effects of chaff, however, any degree of success using this technique would result in total loss of the basic target.

Noise

Noise jammers effect the APS-67 in search the same as the APQ-83B/-124. The APS-67 can detect noise jamming at ranges far beyond its 16 mile normal detection limit. Reducing gain and/or manual tuning is actually a combination of controls superior to either APQ-83B or APQ-124 to counter noise jamming. Reduction of these controls in the search mode until the thinnest possible vertical band of illumination exists and then maneuvering the nose in pitch until the noise illumination is brightest provides the pilot with azimuth and

nose attitude to the target source. There is no valid use of APS-67 in ACQUISITION or TRACK against noise jamming.

Note

Whenever the manual tune switch is utilized to counter the effects of spot noise jamming, it must be repositioned to AUTO to subsequently paint non-noise jamming sources.

Deception

Range and angle deception ECM techniques affect the APS-67 in the same manner as APQ-83B/-124. Since these techniques are not effective when employed against search modes, use of search mode is the proper ECCM procedure.

EFFECTS OF AIR-LAUNCHED DECOYS

Air-launched decoys may be used to cause confusion or to cause interception of the decoy instead of the enemy. The decoy may be launched straight ahead with the enemy making a rapid diving or climbing turn away from the decoy's course. It is also possible that the decoy may be guided to a heading away from the enemy's launching heading allowing the enemy to continue on course. These air-launched missiles will be augmented to have the same reflectivity as that of the enemy bomber. Since the fighter radar cannot distinguish between decoys and true targets, each must be intercepted, identified and/or destroyed, thus decreasing the effective air defense capability of the defending forces.

EFFECTS OF COMMUNICATIONS JAMMING

In a combat situation, it is practically certain that communications jamming or false vectoring will be attempted by the enemy. Since the success of anti-air warfare is dependent upon sustained communications between the fighter and controller, every effort must be made to work through jamming or false vectors. If this is not possible, procedures must be established for broadcasting intercept directions over predetermined alternate frequencies.

Channel Rotation Plan

The task force will establish channel rotation plans. Pilots and controllers must be familiar with the current plan. The brevity code word "chattermark" will be used to indicate that the frequency is being jammed and that channel rotation procedures are to be implemented immediately. The pilot puts the channel rotation into effect by calling the word "chattermark." Channel rotation should be initiated on a prearranged time scale.

Every effort should be made to read through the jamming and transmission during breaks if the jamming is intermittent. When "chattermark" is called, the controller and pilot should immediately change to the first channel listed on the channel rotation plan. If contact is not established within 30 seconds, the next listed channel should be selected. The controller should continue to transmit on the original frequency and simultaneously on the new frequency. This will deny the jammer any knowledge of his jamming effectiveness and will allow the pilot to try the original frequency again should "chattermark" fail.

ADF Function

The ADF function of the AN/ARC-27 radio system provides a limited capability for locating continuous UHF jammers. If this function is to be used, the pilot should first switch to a prearranged SIF code to inform the controller that the fighter is homing on the jammer. When the controller receives the prearranged code, he should make very short transmissions, giving only target range and azimuth, so as not to confuse the ADF.

Meanwhile, the pilot should attempt radar contact with any information he may be able to receive from the air controller. Intermittent UHF jammers that are keyed by the fighter transmitter further limit the usefulness of the ADF function because bearing information is obtained only when the fighter is attempting to transmit and for several seconds after the mike button is released. It takes about five seconds before the bearing needle stabilizes and air controller information is often inaudible during this time. The pilot may be able to get more useful information from the controller than by using the ADF function when encountering intermittent UHF communications jamming.

PART 6 — AIR-TO-AIR MISSILES

AIM-9 IR MISSILE INTRODUCTION

(U)The operational theory and design principles of the AIM-9D and AIM-9B Sidewinder infrared missiles are quite similar although specific design changes in the AIM-9D have resulted in greater tactical capabilities. A discussion of areas in which the two missiles are identical is presented here, followed by a separate detailed examination of both the AIM-9D and AIM-9B.

AIM-9 IR MISSILE GENERAL

(C)(Gp-4) Sidewinder AIM-9B and AIM-9D are both supersonic, air-to-air guided missiles, homing on infrared (IR) energy emitted by the target, either by a jet engine or, to a lesser extent, by reciprocating engines (figure 1–69). This homing is accomplished by a gyro-optical system designed to gather IR energy, process this energy into angular rate data, and produce tracking signals to maintain gyro-optical boresight on the target. The tracking signal is further processed and converted to missile airframe steering by the "torque balance" servosystem. The characteristics of the torque balance servo are such that a lateral acceleration of the missile is produced, which in g's is approximately four times the tracking rate in degrees per second. This 4 to 1 ratio is called the navigation constant and results in the missile flying a collision course to intercept.

(U) Propulsion is provided by a solid propellant, high thrust rocket motor which accelerates the missile to supersonic speeds within seconds after launch.

(C)(Gp-4) Wing assemblies on the aft end of the rocket motor provide aerodynamic stability to the missile. Roll, pitch, and yaw damping are enhanced by the use of airstream-driven gyros (rollerons) located on the outboard trailing edge of each of the four wings.

(U) The warhead is detonated by contact fuzing upon striking the target or by influence fuzing in the event of a near miss. If the missile fails to intercept the target, the warhead will detonate on a gas generator burnout. Cockpit controls for Sidewinder missiles are presented in figure 1–69A.

CAPTIVE FLIGHT

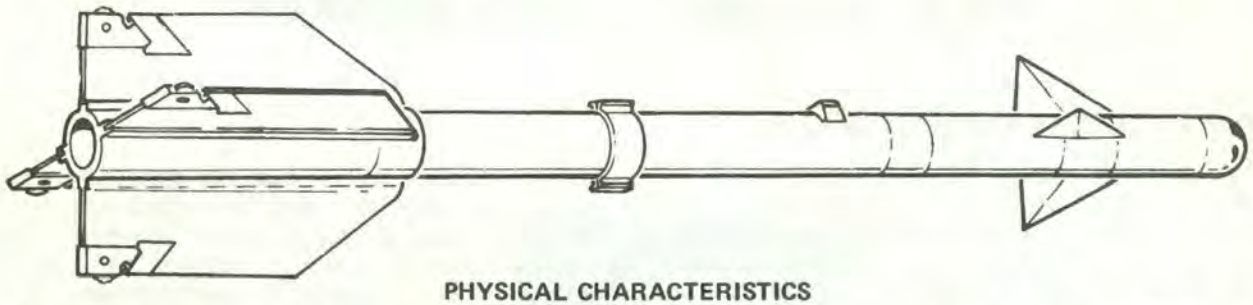
(C)(Gp-4) During captive flight the gyro optics are electrically caged along the missile axis which is aligned with the aircraft armament datum line and, therefore, the fixed gunsight. Electrical power is supplied by the aircraft through the power supply in the missile launcher. An audio tone heard by the pilot will indicate the presence of an IR source within the missile field of view. This IR source represents a potential target for the missile. The missile has no means of target identification and will home on friendly as well as hostile aircraft. Sun reflections off clouds and certain terrain features will also produce audio tones. Point sources of IR energy such as jet airplane tailpipes can be distinguished from an IR energy reflecting background; however, it takes practice on the part of the pilot to identify the true target under these conditions. Identification of an IR point source against an IR background is made possible through modulation of Ir energy by a rotating reticle placed in the optical path. The characteristics of the reticle are such that little or no modulation (audio tone) is obtained when the target is centered in the missile field of view. This loss of audio tone or pull can be mistakenly interpreted as a loss of target.

LAUNCH PHASE

(C)(Gp-4) Concurrently with activation of the firing circuit, the gyro-optics are uncaged and the gas generator is ignited. After being uncaged, the gyro-optics automatically track the target and, as the seeker zeroes on the target, a null occurs resulting in a loss of audio tone. The gas generator drives the turboalternator which supplies electrical power to the guidance section and pneumatic power to the torque balance servosystem. When the turbo-alternator output achieves a specified voltage and frequency, a firing relay in the aircraft launcher power supply closes to both ignite the rocket motor and activate the thermal battery in the fuze. The time from activation of firing circuit to missile launch varies from 0.4 to 0.8 second. The servo section is disabled for at least 0.4 second after launch, which allows the missile to clear the firing aircraft before maneuvering. The complete (approximate) firing time sequence for the AIM-9D and AIM-9B is shown in figure 1–70.

(U) The specific design characteristics and the resulting tactical capabilities for each missile will be discussed separately in subsequent paragraphs of this section.

AIM-9B, -9C, -9D Guided Missile



PHYSICAL CHARACTERISTICS

Weight (AIM-9B) – 155 pounds
(AIM-9C) – 210 pounds
(AIM-9D) – 189 pounds

Diameter (ALL) – 5 inches

Length (AIM-9B) – 112 inches
(AIM-9C) – 119 inches
(AIM-9D) – 113 inches

Suspension (AIM-9B) – LAU-7A or – Aero-3A
(AIM-9C) – LAU-7A
(AIM-9D) – LAU-7A

DESCRIPTION

The Sidewinder guided missile is a supersonic air-to-air homing weapon employing infrared or radar target detection, proportional-navigation guidance and torque-balance control. The missile is launched from a rail-type launcher. The AIM-9B and -9D are infrared detecting missiles with the -9D having nitrogen cooling for the guidance and control section, longer motor burning time and the ability to operate at higher altitudes. The AIM-9C is a radar detecting missile with capabilities similar to the AIM-9D.

FUSELAGE STATION LOADING CONFIGURATIONS

FUSELAGE LOADING	EQUIPMENT-WEIGHT	
LAU-7A SUSPENSION Dual Pylon	4 AIM-9C 4 LAU-7A 2 Pylons	840 368 140
	Total One Side Only	1,348 674
AERO-3A SUSPENSION Single Pylon	2 AIM-9B 2 Aero 3A 2 Pylons	310 98 108
	Total One Side Only	516 258

REFERENCES

1. Restrictions – See Figure 2-2
2. Missile Arming Procedures – NAVAIR 01-45HH-75
3. Preflight Inspection – NAVAIR 01-45HH-75
4. Missile Loading Procedures – NAVAIR 01-45HH-75

FIRING PROCEDURES

1. Master Arm Sw – ON
2. Armament Sel Sw – Desired Station
3. IR-Radar Light – CHECK
4. Stores Release Sw – DEPRESS

NOTES

The LAU-7A and the Aero 3A can be attached to either a single or a dual fuselage pylon.

The weights shown are only for the combinations shown.

Armament Sel Sw will automatically step to the next clockwise fuselage station when a missile is fired on F-8C, H, J and K aircraft.

Armament sel sw will automatically step only when the left fuselage station is selected on F-8A, B and L aircraft.

IR missile cooling is provided for the AIM-9D missile and is controlled by the pilot.

JETTISONING PROCEDURES

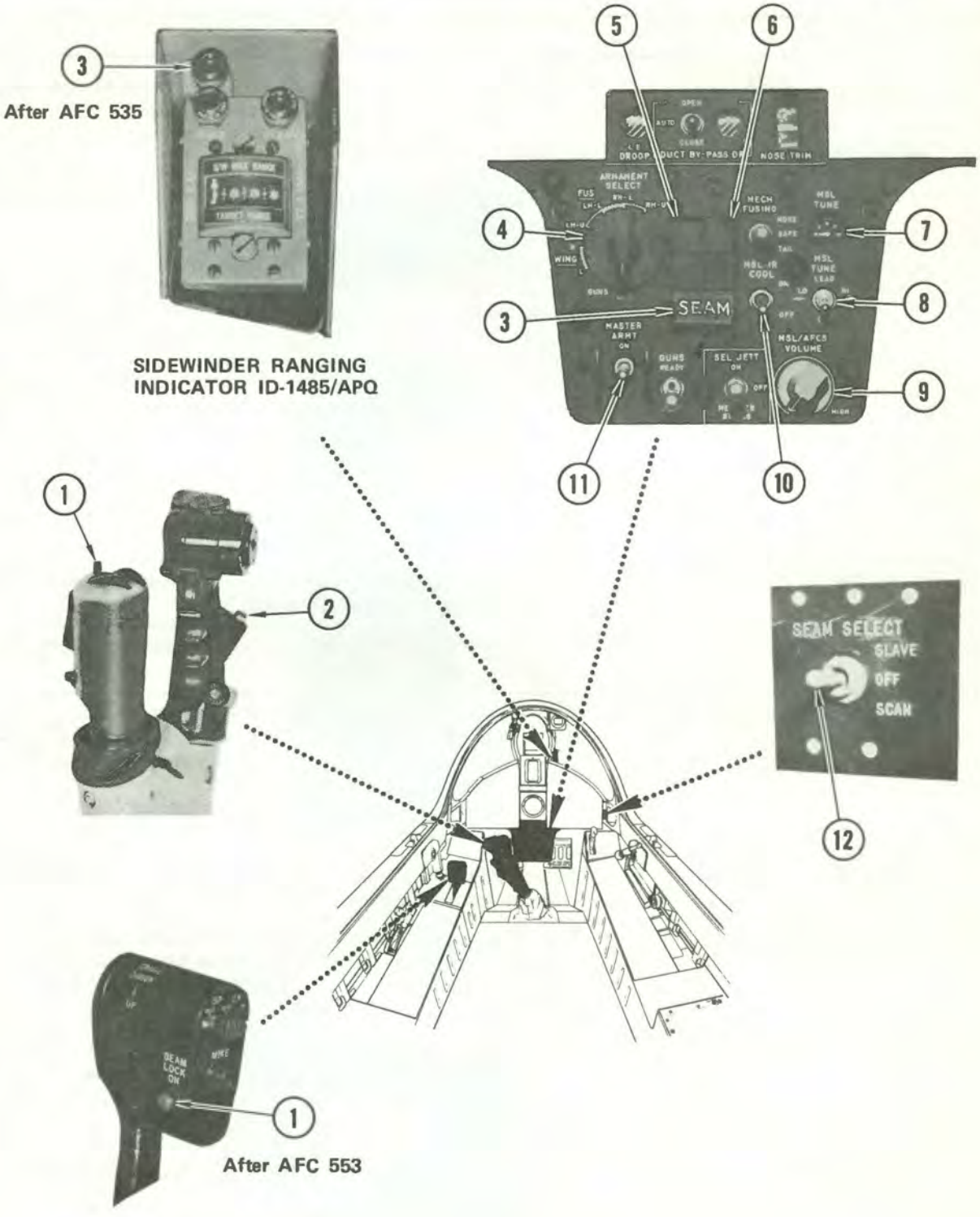
SALVO JETTISON SWITCH
LW/FU – Jettisons stores on left wing and upper fuselage pylons.
RW/FL – Jettisons stores on right wing and lower fuselage pylons.

SELECT JETTISON SWITCH
ON – Jettisons stores selected by the Arm Sel Sw

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Figure 1-69

Sidewinder Cockpit Controls



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Figure 1-69A (C) (Sheet 1)

Sidewinder Cockpit Controls

	Nomenclature	*Function*
1.	SEAM lock-on button	DEPRESSED – locks/unlocks AIM-9G seeker head when operating in SCAN mode only. Inoperative when in SLAVE mode.
2.	Stores release button	Depressed – fires selected fuselage system store.
3.	SEAM advisory light	LIGHTED (SEAM)– indicates AIM-9G seeker has locked on target, when either mode of SEAM operation is selected.
4.	Armament selector switch	MSL or FUS, LH-U, LH-L, RH-L, RH-U; MSL – permits selection of one of four fuselage missile stations. Switch automatically steps to next clockwise fuselage position when a missile is fired. Energizes missile release computer for type of missile loaded on selected station. Connects missile acquisition tone signal to headset. WING, L or R – permits selection of one of the two wing pylon stations. Switch is manually placed in the position to be fired, and will not step automatically after firing. OFF – safe position; disconnects firing circuit. Also permits check of gun mode resistors.
5.	IR light	On indicates Sidewinder missile having infrared guidance is loaded on station selected by armament select switch.
6.	Radar light	On indicates Sidewinder missile having radar guidance is loaded on station selected by armament select switch.
7.	Missile tuning meter	Maximum clockwise deflection indicates frequency of AIM-9C missile receiver is tuned properly.
8.	Missile tuning/lead launch switch	LO – adjusts AIM-9C missile guidance receiver to a lower frequency. HI – adjusts AIM-9C missile guidance receiver to a higher frequency. OFF (lower centered) – tune circuit open and deviated pursuit computer output removed from radar set. LEAD – (centered position) – tune circuit open and deviated pursuit computer output applied to radar set.
9.	Missile/AFCS volume knob	Controls volume of missile acquisition tone and tone signals generated by fire control computer group from LOW to HIGH.
10.	IR missile cooling switch	ON – supplies power from secondary dc bus to nitrogen cooling bottle circuit in each LAU-7/A launcher. When AIM-9D missile is being carried, should be turned ON at least one minute before firing. OFF – deenergizes cooling system.
11.	Master armament switch	ON – with landing gear retracted, connects secondary dc power through armament bus and master arm relay to gun arming switch and trigger switch and stores release button. Connects secondary ac bus power to gun interlock.
12.	SEAM select switch	SCAN – enables AIM-9G seeker head to increase its field of view from 2.5° to 7.5° about the boresight line. OFF – deenergizes SEAM system. SLAVE – slaves AIM-9G seeker head to radar antenna when radar is in TRACK mode. Enables AIM-9G to increase its field of view from 2.5° to 7.5°.

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Figure 1-69A (C) (Sheet 2)

AIM-9B/D Time Sequence

TRACKING TARGET OPERATION

TIME (SEC)	AIM-9B	AIM-9D
0	1. Firing button 2. Gas generator ignition 3. Gyro optics uncage	1. Firing button 2. Gas generator ignition 3. Gyro optics uncage 4. Unlock arming mechanism – Mk 13 S&A device
+0.60	Turbo alternator up to voltage and frequency	Turbo alternator up to voltage and frequency
+0.65	Launcher firing relay closes	Launcher firing relay closes
+0.70	1. Rocket motor ignition 2. Mk 303 influence battery activated	1. Rocket motor ignition 2. TDD battery activated
+0.80	1. Missile launch (umbilical shear) 2. Mk 304 fuze firing circuit protector (electrical ground) removed 3. Rollerons uncage	1. Missile launch (umbilical shearer) 2. Rollerons uncage
+1.20	Steering capabilities initiates (Command signals applied to servo)	Steering capabilities initiates (Command signals applied to servo)
+2.0	Mk 304 fuze mechanically armed	
+2.6		Mk 13 S&A fully armed
+2.8	Motor burnout	
+3.3	Mk 303 fuze fully armed	
+5.8		Motor burnout
+21.0	1. End of guidance 2. Self destruct	
+60.0		1. End of guidance 2. Self destruct

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Figure 1–70

AIM-9D AIR-TO-AIR MISSILE

The AIM-9D is one of the most effective missiles in the world today for use in the maneuvering air combat environment and is considered the primary armament of F-8 aircraft. It is designed for use against high or low speed aircraft flying at altitudes between sea level and 80,000 feet and can be fired either visually or as an integral part of the radar system.

AIM-9D COMPONENT DESCRIPTIONS

The AIM-9D consists of the guidance and control group (GCG), Target Detecting Device (TDD), Safe-Arming Device (S&A), warhead, rocket motor, and wing assemblies. See figure 1–70A.

Guidance Control Group

The gyro-optics system is enclosed within the streamlined shape of the guidance and control unit just behind the translucent IR dome. The magnesium fluoride dome material was chosen because of its heat transfer and IR spectrum transmission characteristics. The streamlining of the nose section was possible due to the miniaturization of the gyro-optics assembly.

The gyro seeker unit has a field of view of 44 mils (2.5°) with a gimbal limit of 40° from the missile longitudinal axis. The maximum gyro tracking rate is 12° per second but varies in relation to IR signal to noise ratio and the degree to which the seeker unit boresight is displaced from the missile longitudinal axis.

Seeker sensitivity has been greatly increased over earlier missiles by the addition of a nitrogen cooling system which cools the detector to the temperature of liquid nitrogen (–196°C). This provides the additional benefit of improved target to background discrimination by shifting the response of the detector away from solar radiation temperature and toward tailpipe temperature. The relatively small field of view plus improved optical filtering also contribute greatly to improved detection and target to background discrimination. AIM-9D guidance time is 60 seconds as limited by gas generator burning time.

Target Detection Device

The two target detection devices (TDD) available for the AIM-9D are the Mk 24 IR unit and the Mk 15 radio frequency (RF) unit. The latter has proven superior in the maneuvering target environment and is the only one recommended for use in the environment. The Mk 24 TDD is maintained for use against bomber type targets.

The TDD is mechanically attached to the GCG. An internal electrical cable between the GCG and TDD provides the electrical transfer functions necessary between the two units. The TDD thermal battery is fired by the launcher power supply through the GCG umbilical cable.

Although the Mk 15 TDD has been demonstrated to be superior to the Mk 24 TDD in a maneuvering target environment, lethality of the weapon system is still low in those cases in which a high track crossing angle at intercept exists. This is because of the critical timing required for warhead detonation and the small projected area of the target that is vulnerable to the warhead. In order to maximize the probability of a kill, every effort should be made to attain a low TCA, tail-on launch aspect in a range well away from the boundaries of the launch envelope. Of course, a firing opportunity should not be passed up unless the high probability exists that a more favorable position can be attained.

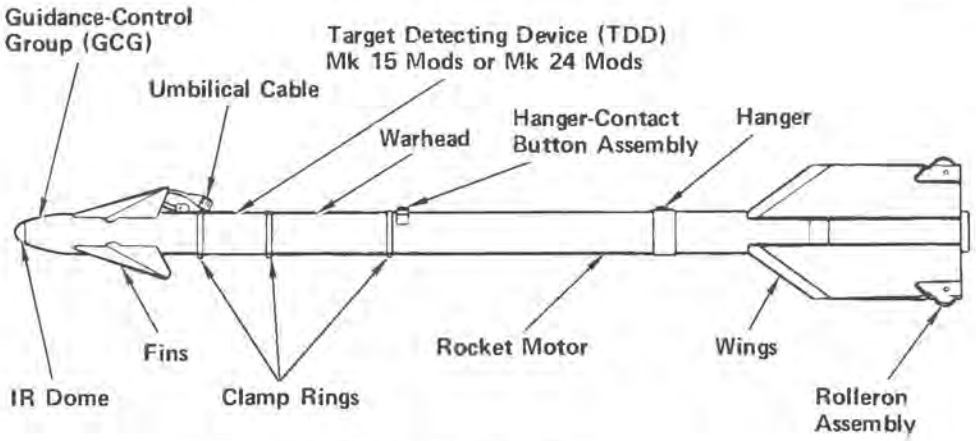
Safe-Arming Device

The safe-arming (S-A) device attaches to and is electrically mated with the target detection device and contains a mechanism sensitive to missile acceleration. It is mechanically locked in the safe position until aircraft voltage is applied through the GCG from the firing circuit. The acceleration sensitive mechanism rotates to the armed position while the missile travels from 600 to 1,000 feet ahead of the launch airplane. During this period the GCG provides the voltage to the mechanical lock to allow the acceleration to arm the S-A device. An explosive train in the S-A device is actuated by the TDD, or the contact or self-destruct circuits of the GCG, which in turn detonates the booster in the warhead.

Warhead

The warhead is a continuous rod type constructed of a bundle of ⅜-inch square steel rods 10 inches long and welded together at alternate ends. Upon detonation the rod bundle expands at right angles to the missile at a rate of 4,000 feet per second to a maximum radius of 17 feet. The forward velocity of the missile is also imparted to the continuous rod which causes it to move forward as well as laterally in the shape of a cone with the point of the cone at the point of detonation. This steel ring can knife through the toughest aircraft structures. The continuous rod does not depend on blast effect for damage; therefore its destructiveness is not degraded with an increase in altitude.

AIM-9D/AIM-9G Missile



CHARACTERISTICS

Motor Burn Time	–	5.0 Seconds
Thrust	–	3,500 Pounds
Speed	–	2.5 Mach (above launch speed)
Guidance Time	–	60 Seconds
Warhead Type	–	Continuous Rod
Warhead Lethal Radius	–	17 Feet
Minimum Range	–	1,000 Feet
Turn Capability	–	18G at Sea Level
Cool Down Time	–	60 Seconds
Field of View	–	44 Mils (2.5 degrees)
Gimbal Limit	–	40 Degrees
Gyro Tracking Rate	–	12°/Second

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Figure 1–70A (C)(Gp-4)

Rocket Motor

A single stage high performance solid propellant motor providing an average of 2,800 pounds of thrust for 5.0 seconds boosts the AIM-9D to 2.5 Mach above the speed of the launch aircraft. Following motor burnout, the missile coasts for the remainder of its 60-second guidance time or until it decelerates to speeds below which guidance is unreliable.

Wing Assembly

Four wings with rollerons are mounted on the aft end of the motor for lift and stability. In captive flight the rolleron housing is mechanically caged and is uncaged during acceleration just after launch. The rollerons are free to turn while the missile is either captive or in flight. The gyroscopic action of the spinning rolleron produces motion in the housing which acts aerodynamically to counteract the tendency to roll and also provides pitch and yaw damping.

AIM-9D MISSILE ENVELOPE PARAMETERS

All minimum and maximum launch boundaries presented in figure 1–70B are determined by simulation of the flight characteristics of the missile. They are the minimum values that you can expect 50% guidance success. The probability of success increases rapidly as you approach the "heart of the envelope."

R_{min} Envelope

The seeker tracking rate is most often the limiting factor, in determining an absolute value for R_{min}. Tracking rate is dependent on the IR signature of the target which varies with target type, engine power setting, bank and aspect angles, and environmental conditions. A nominal value of maximum seeker tracking capability has been assumed without regard for the actual IR signature in order to separate the kinematic and IR characteristics of the missile. A tracking rate of 8° per second was assumed. This figure has

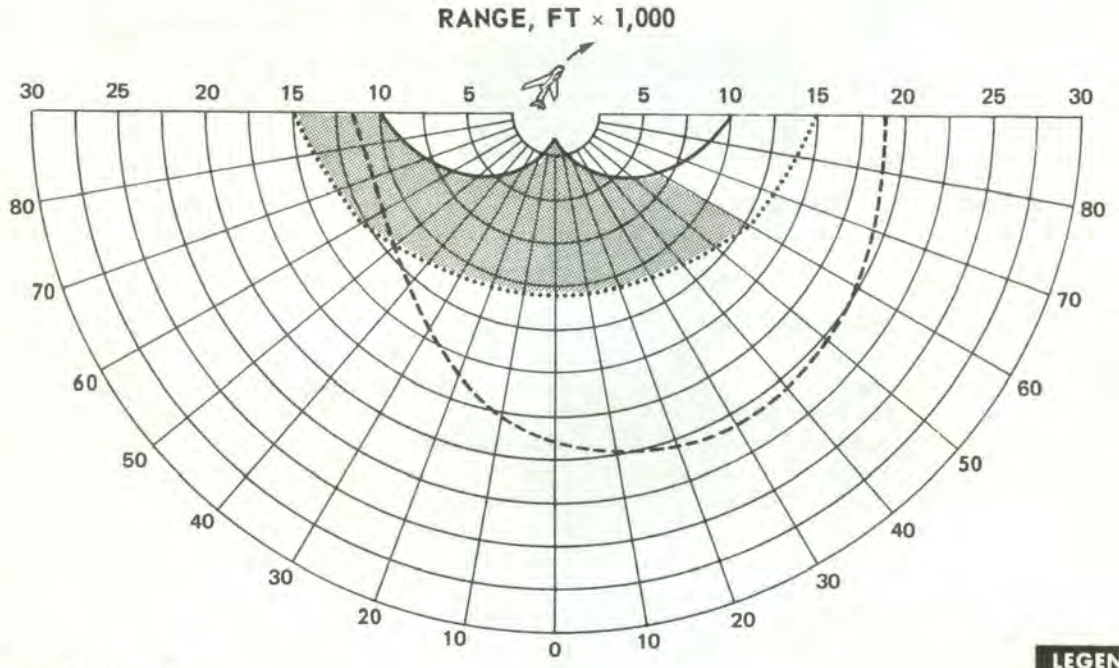
AIM-9D Launch Envelopes

MANEUVERING AND NON-MANEUVERING TARGETS

NOTE

All G's are target G's measured in horizontal plane.

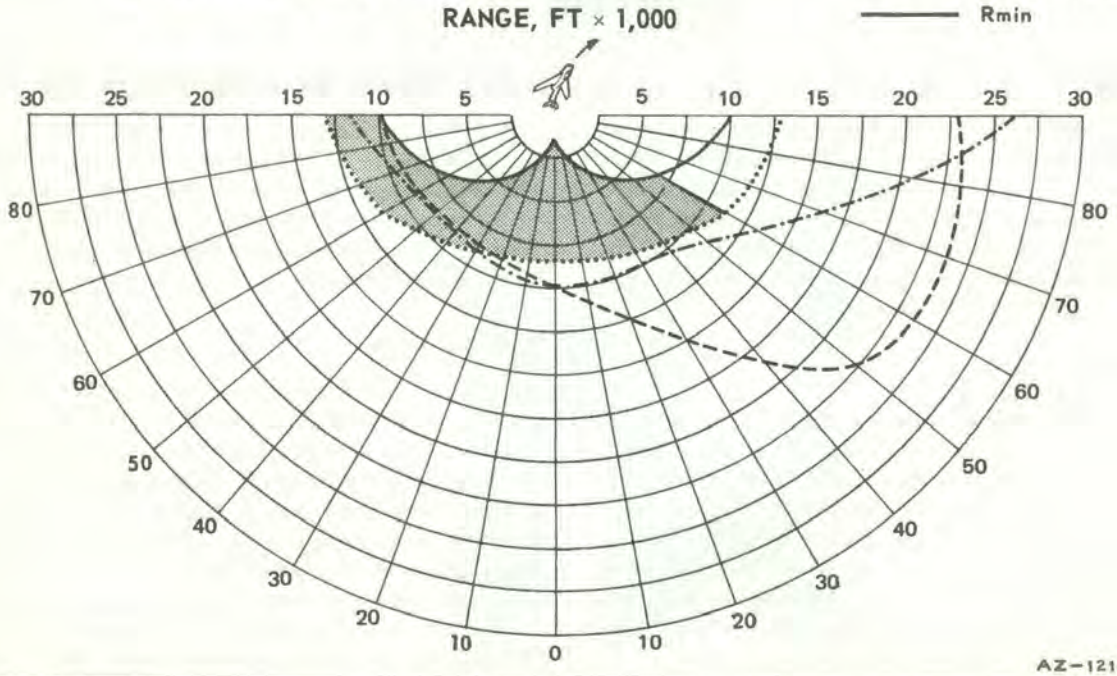
Co-Altitude – Sea Level
Co-Speed – 0.6 IMN
Target Maneuver – Instantaneous horizontal right turn, constant G and airspeed



Co-Altitude – Sea Level
Co-Speed – 0.8 IMN
Target Maneuver – Instantaneous horizontal right turn, constant G and airspeed

LEGEND

- ..... Non-Maneuvering Rmax
- -·-·-·- 3G Maneuvering Rmax
- – – – – 5G Maneuvering Rmax
- ——— Rmin



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Figure 1–70B (Sheet 1)

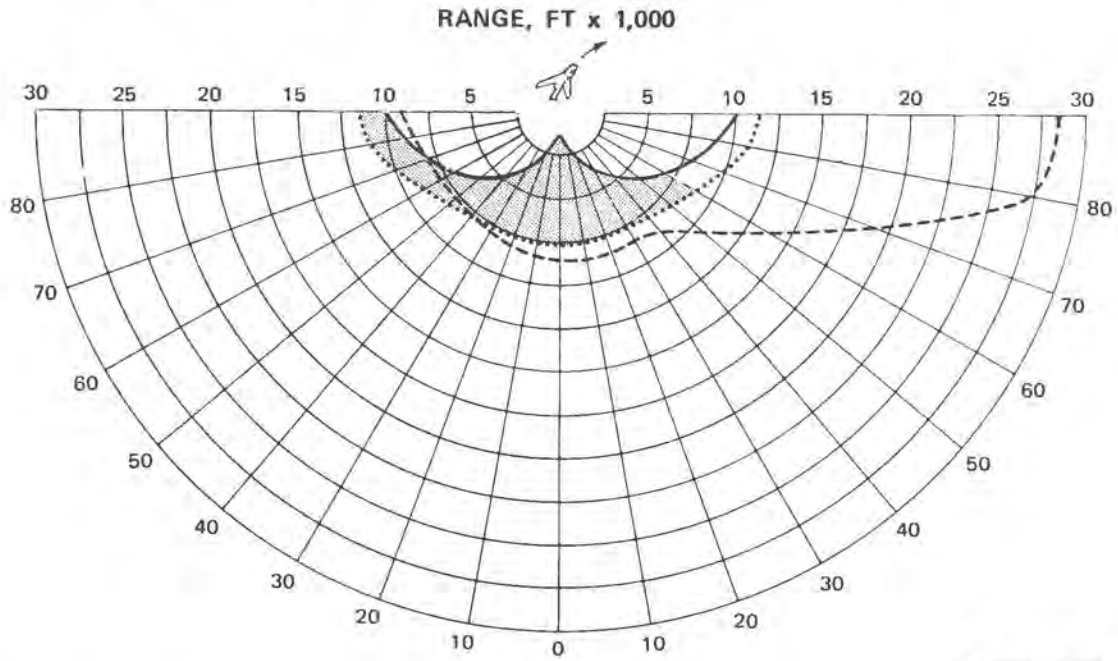
AIM-9D Launch Envelopes

MANEUVERING AND NON-MANEUVERING TARGETS

Co-Altitude – Sea Level
Co-Speed – 1.0 IMN
Target Maneuver – Instantaneous horizontal right turn, constant G and airspeed

NOTE

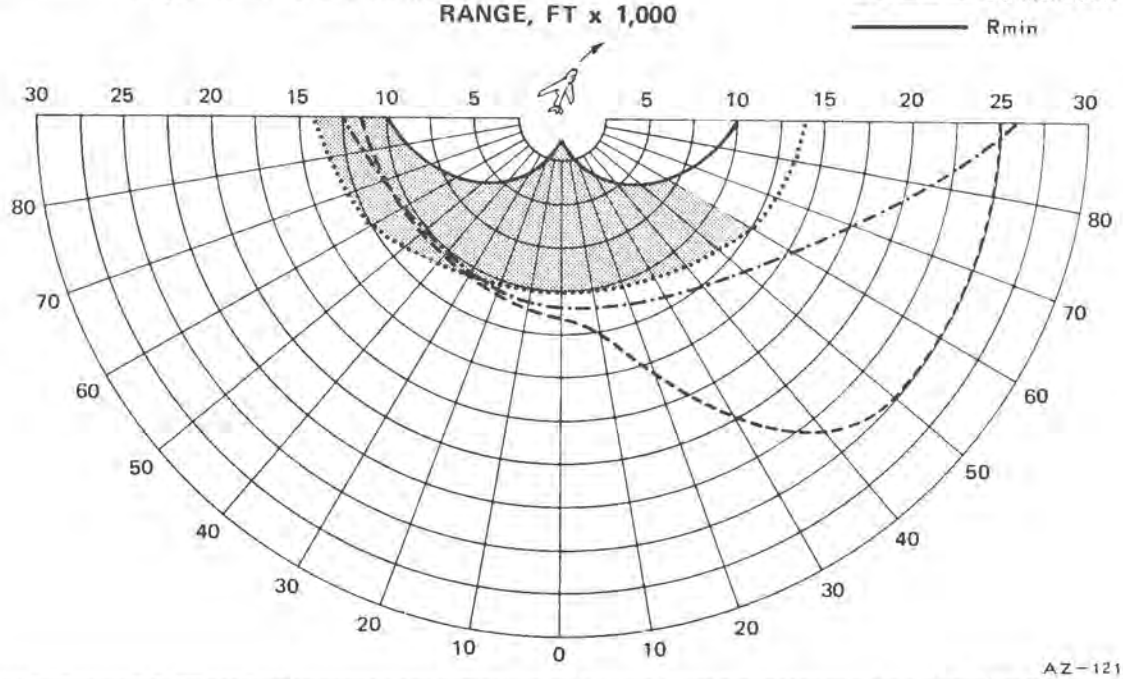
All G's are target G's measured in horizontal plane.



Co-Altitude – 5,000 Feet
Co-Speed – 0.8 IMN
Target Maneuver – Instantaneous horizontal right turn, constant G and airspeed

LEGEND

- ..... Non-Maneuvering Rmax
- -·-·-·- 3G Maneuvering Rmax
- – – – – 5G Maneuvering Rmax
- ——— Rmin



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Figure 1–70B (Sheet 2)

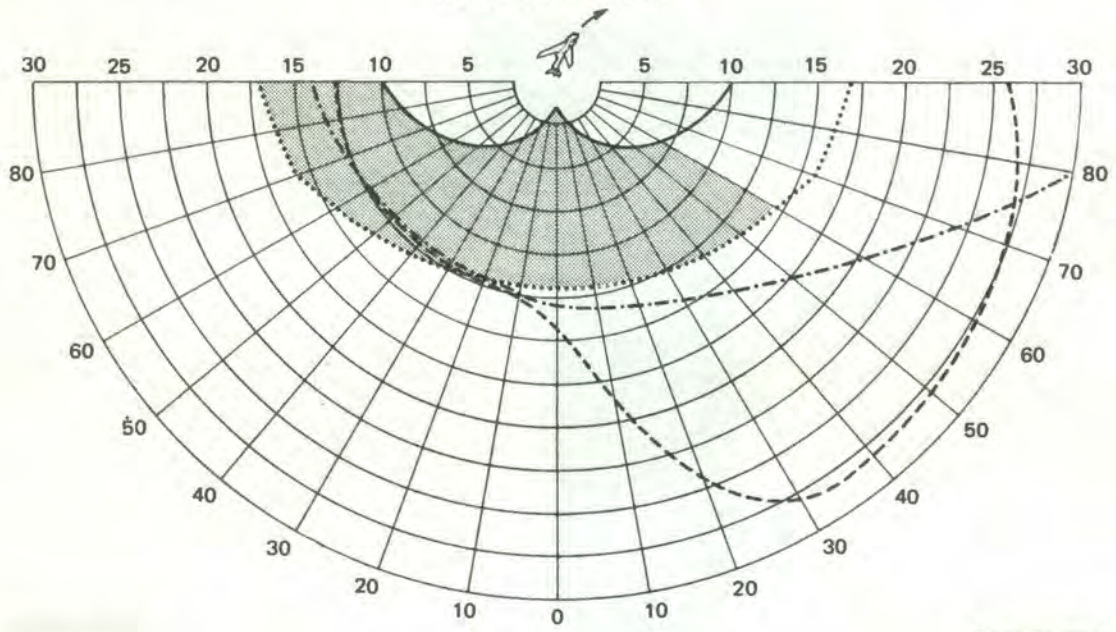
AIM-9D Launch Envelopes

MANEUVERING AND NON-MANEUVERING TARGETS

NOTE

All G's are target G's measured in horizontal plane.

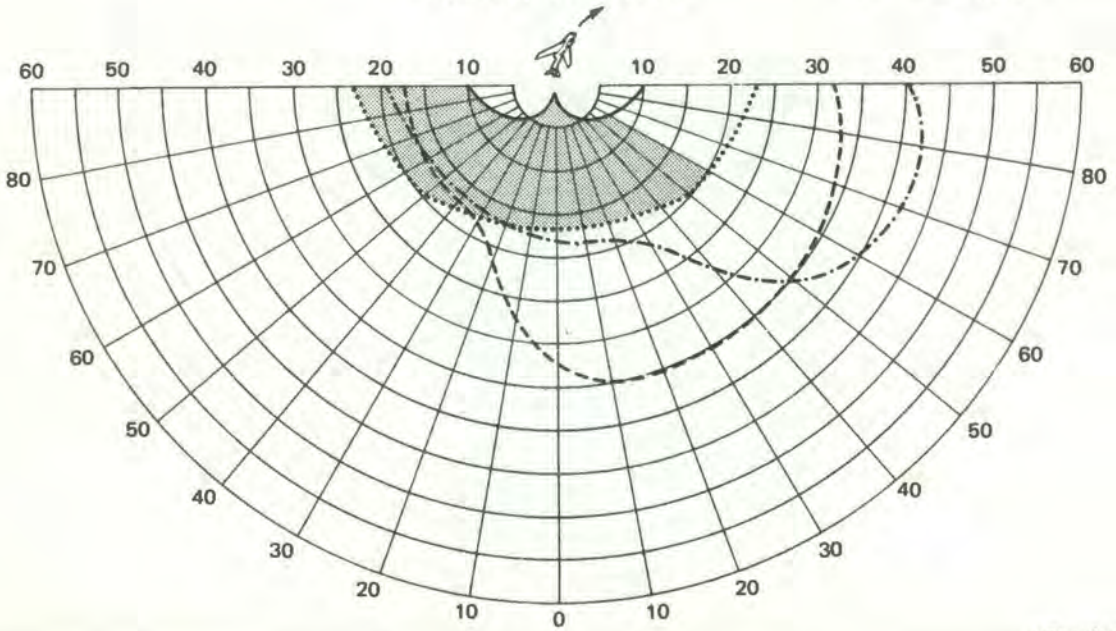
Co-Altitude – 10,000 Feet
Co-Speed – 0.8 IMN
Target Maneuver – Instantaneous horizontal right turn, constant G and airspeed



Co-Altitude – 20,000 Feet
Co-Speed – 0.8 IMN
Target Maneuver – Instantaneous horizontal right turn, constant G and airspeed

LEGEND

- ..... Non-Maneuvering Rmax
- -·-·-·- 3G Maneuvering Rmax
- – – – – 5G Maneuvering Rmax
- ——— Rmin



AZ-121(3)-03-69

Figure 1-70B (Sheet 3)

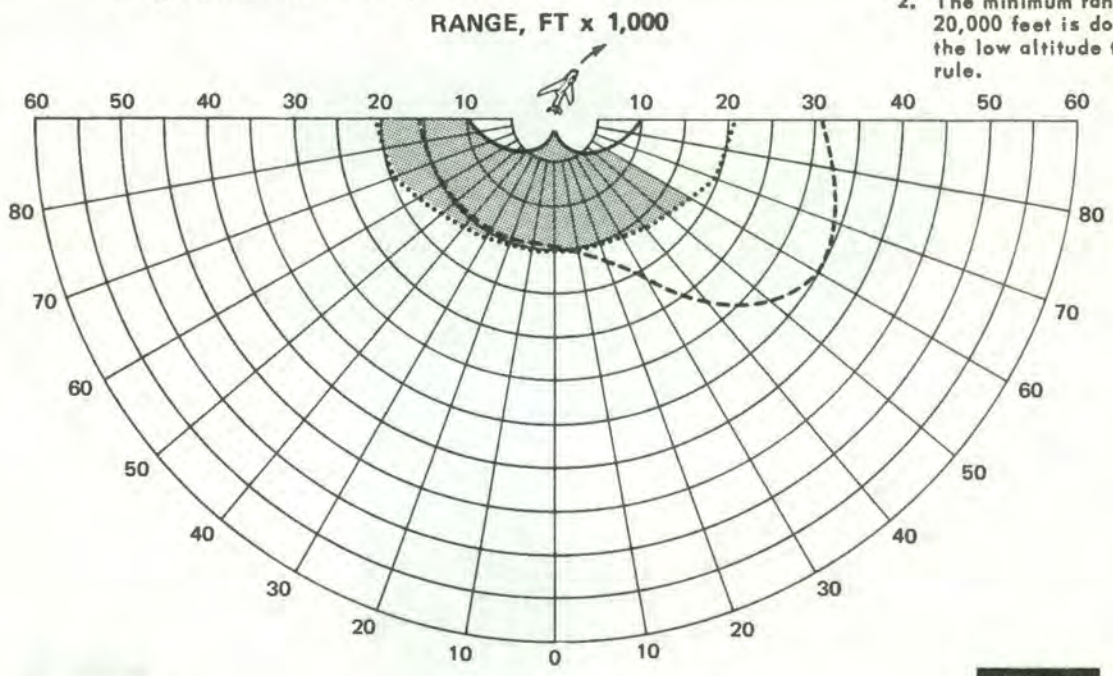
AIM-9D Launch Envelopes

MANEUVERING AND NON-MANEUVERING TARGETS

NOTES

1. All G's are target G's measured in horizontal plane.
2. The minimum range above 20,000 feet is double the low altitude thumb rule.

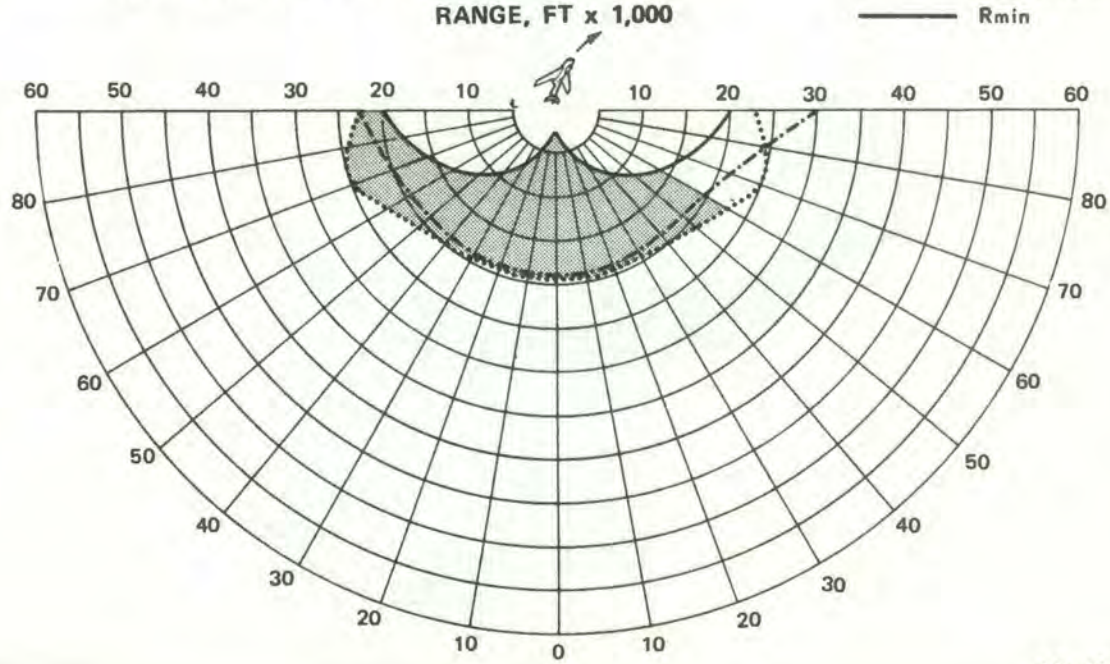
Co-Altitude – 20,000 Feet
Co-Speed – 1.0 IMN
Target Maneuver – Instantaneous horizontal right turn, constant G and airspeed



Co-Altitude – 30,000 Feet
Co-Speed – 1.2 IMN
Target Maneuver – Instantaneous horizontal right turn, constant G and airspeed

LEGEND

..... Non-Maneuvering Rmax
–·–·–·– 3G Maneuvering Rmax
– – – – – 5G Maneuvering Rmax
——— Rmin



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Figure 1-70B (Sheet 4)

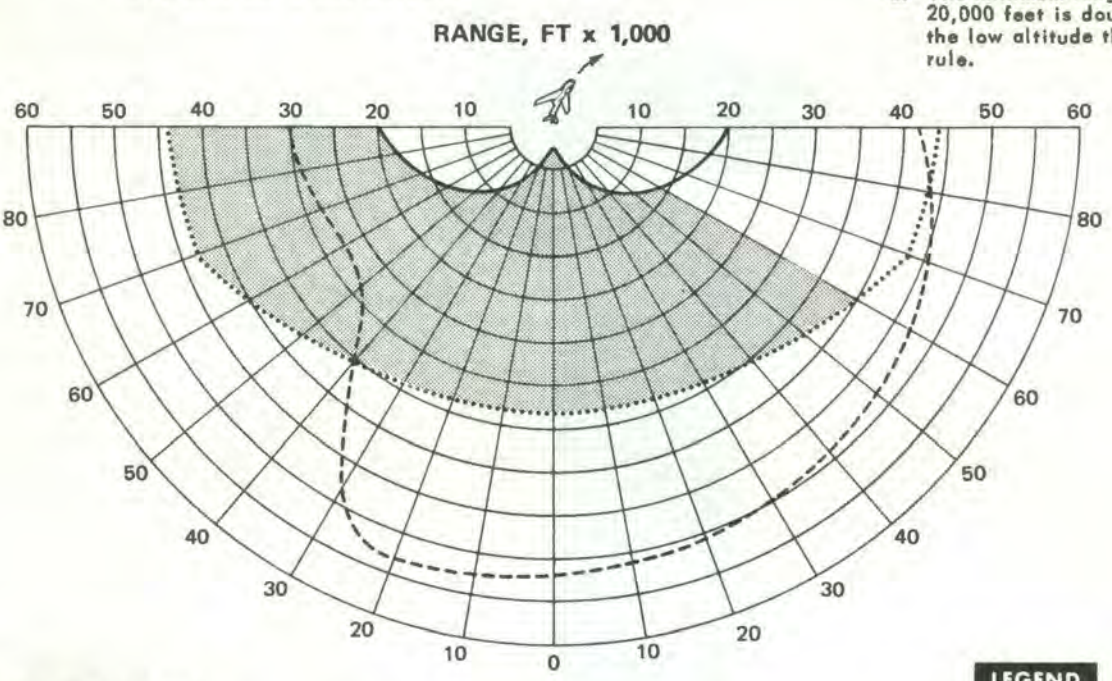
AIM-9D Launch Envelopes

MANEUVERING AND NON-MANEUVERING TARGETS

Co-Altitude – 40,000 Feet
Co-Speed – 1.0 IMN
Target Maneuver – Instantaneous horizontal right turn, constant G and airspeed

NOTES

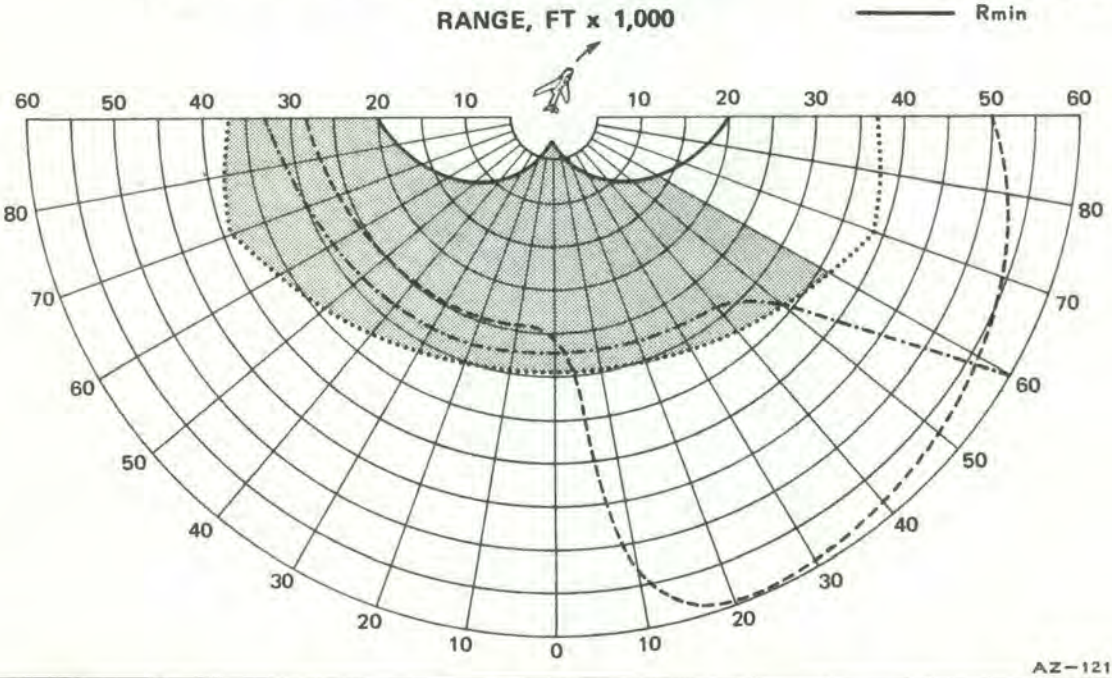
1. All G's are target G's measured in horizontal plane.
2. The minimum range above 20,000 feet is double the low altitude thumb rule.



Co-Altitude – 40,000 Feet
Co-Speed – 1.2 IMN
Target Maneuver – Instantaneous horizontal right turn, constant G and airspeed

LEGEND

- ..... Non-Maneuvering Rmax
- -·-·-·- 3G Maneuvering Rmax
- – – – – 5G Maneuvering Rmax
- ——— Rmin



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Figure 1-70B (Sheet 5)

been chosen for kinematic simulation purposes based on expected flight conditions. It has been an appropriate choice in that it corresponds fairly well with the aerodynamic maneuverability limitations of the missile.

The point in an envelope where the seeker is no longer able to track is easily determined by the angular difference between the firing airplane and the target. R_{min} for the AIM-9D at 0° angle off, co-speed, in the maneuvering target environment is 1,000 feet as determined by fuze arming time. As the angle off increases, R_{min} will increase very rapidly. Because of the difficulty in ascertaining the precise launch conditions during a rapidly changing air combat maneuvering situation, the following rule of thumb is recommended:

MINIMUM LAUNCH RANGE EQUALS 1,000 FEET PLUS AN ADDITIONAL 1,000 FEET FOR EACH 10° ANGLE OFF.

For example, under a condition of 40° angle off, the minimum launch range would be $1,000 + (4 \times 1000) = 5,000$ feet. Adherence to this rule should result in successful intercept of all subsonic targets at altitudes of less than 20,000 feet.

R_{max} Envelope

The determination of R_{max} is somewhat more difficult. The degree of target maneuver has a profound effect on R_{max}. It is possible under some maximum range shots for the target to turn more than 180° prior to missile intercept. This situation essentially places the missile in a forward quarter intercept. Under these conditions, a successful intercept is doubtful since the missile's envelope boundary is completely dependent on the target maintaining a constant speed, g, and large IR source (afterburner).

Note

For the reasons above and because no testing has been accomplished in this area, firing is not recommended outside the non-maneuvering boundary.

For targets turning toward the missile launching aircraft, regardless of g, no degradation to the non-maneuvering launch envelope is present. Therefore, the problem becomes that of determining the maximum range for the non-maneuvering target situation. An easily remembered rule of thumb may be applied (figure 1–70C):

MAXIMUM LAUNCH RANGE IS 1 TO 2 MILES AT SEA LEVEL AND INCREASES BY 1 NAUTICAL MILE FOR EACH 10,000 FEET OF ALTITUDE.

In addition to the basic rule, the following guide should be remembered. The smaller number applies for direct tail-on attacks or if the target has a speed advantage. The larger number applies for medium and high angle off attacks or whenever the fighter has a speed advantage.

Target Load Factor

The target maneuvers listed in the envelopes refer to the horizontal component of the total airplane load factor. Thus, reference to a 5g turn implies, in addition to the 5g horizontal component, a 1g vertical component giving a total load factor of slightly greater than 5g.

Target g has a significant effect on the AIM-9D envelope because of its direct relationship to angle off (referred to as TCA [track crossing angle] during missile flight). As the angle off the target increases, an increased turning performance on the part of the missile is required to make the corrections necessary to intercept the target. This condition can only be satisfied by allowing greater time and distance (increasing R_{min} as angle off increases) for the missile to perform the necessary maneuvers. The envelopes assume that the target turns at the instant the missile is fired and continues its turn until intercept.

Effects of Differential Speed

The aerodynamic range envelope is affected by a differential speed between attacker and target. A launching aircraft speed advantage, singularly considered, causes minimum range to increase (displace the entire envelope aft from the direction of target flight). A target speed advantage has the opposite effect. This relationship can be expressed with the following formula:

$$R = R_c \times (1 + 2 \triangle \text{Mach})$$

where

$R = R_{min}$
R_c = Co-Speed R_{min}
$\triangle$ Mach = Differential Mach in tenths

Example: Determine R_{min} with a 0.2 Mach closure.

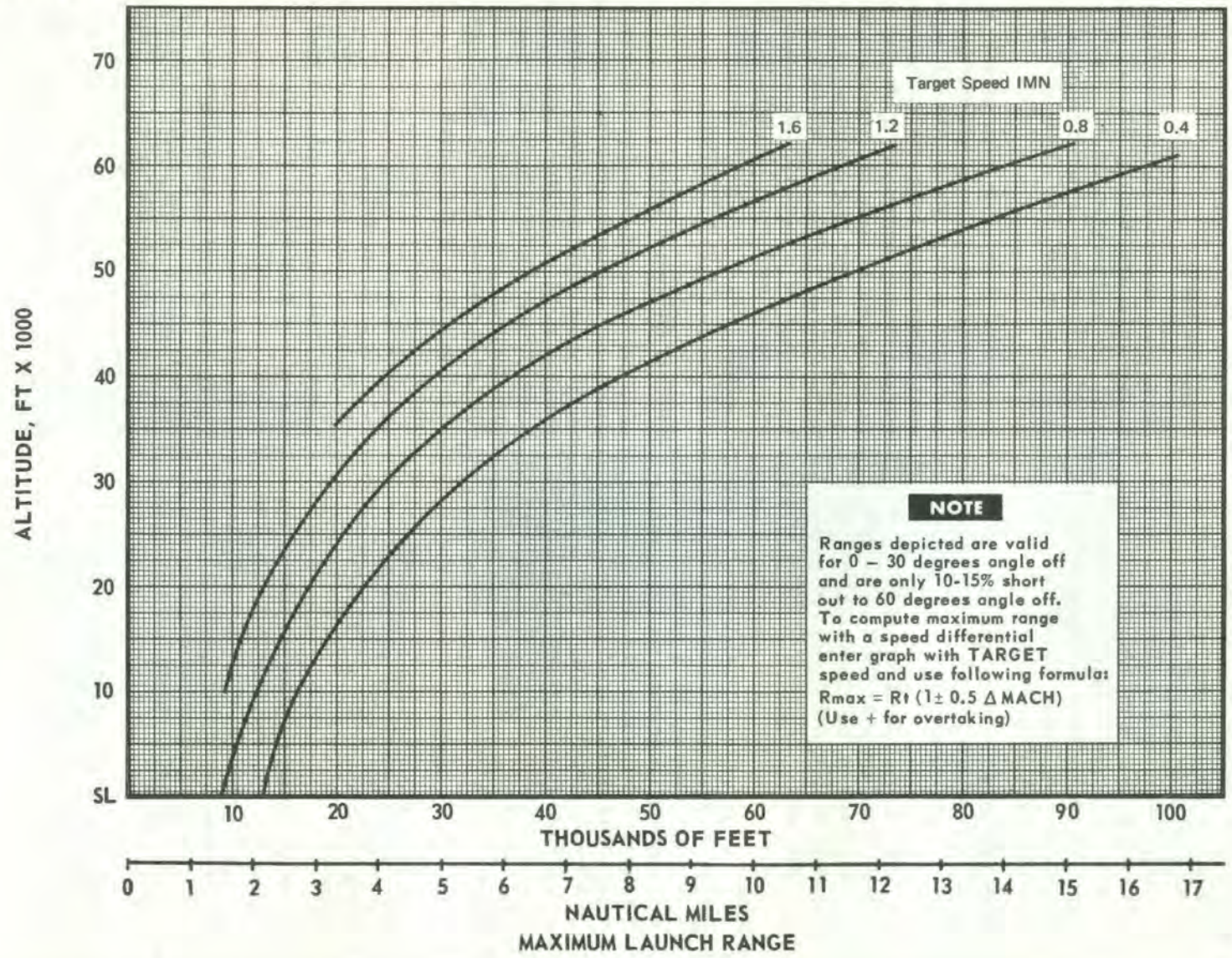
$R_{min} = 1,000 \times (1 + 2 \times 0.2)$
$R_{min} = 1,400$ feet

AIM-9D OPERATIONAL APPLICATIONS

The IR signature of any aircraft will vary with aircraft type, flight attitude, and power settings, as seen by the missile. In general, the IR source of any aircraft is decreased as angle off or TCA increases. At high power settings in basic engine or in burner, the IR source may be sufficient for detection and guidance from all aspects. But in view of the general tendency

AIM-9D Maximum Launch Range

CO-SPEED, CO-ALTITUDE, TAIL-ON ATTACK



AZ–270–12–67

Figure 1–70C

toward degradation of the IR source as angle off increases, it is recommended that missile launch be accomplished as close to 0° angle off as possible, with 60° as an acceptable maximum.

It is important to note that the R_{min} thumb rule begins to break down at angles off greater than 90° and is not usable in the forward quarter.

Effects of Differential Speed

The aerodynamic range envelope is affected by the differential in speed between the attacker and the target. In considering an attack from the 6 o'clock area, a launching aircraft speed advantage will have the effect of increasing both R_{max} and R_{min} (the entire envelope is displaced aft from the direction of target flight). A target speed advantage has the opposite effect. This relationship can be expressed with the following formulas:

$$R_{min} = 1{,}000\ (1 + \hat{2}\ \triangle \text{Mach})$$

where

$\triangle$ Mach is closing velocity

Example: Determine R_{min} with a closure rate of 0.2 Mach.

$$R_{min} = 1{,}000\ [1 + 2\ (0.2)]$$
$$= 1{,}000\ (1 + 0.4)$$
$$= 1{,}000\ (1.4)$$
$$= 1{,}400 \text{ feet}$$

$$R_{max} = R_c\ (1 + 0.5\ \triangle \text{Mach})$$

where

R_c is cospeed R_{max} (based on target speed) and
$\triangle$ Mach is closing velocity

Example: Determine R_{max} when cospeed R_{max} is 2 miles and closing velocity is 0.3 Mach.

$$R_{max} = 2\ [1 + (0.5 \times 0.3)]$$
$$= 2\ (1 + 0.15)$$
$$= 2\ (1.15)$$
$$= 2.3 \text{ miles}$$

Fuzing

The IR fuze (Mk 24 TDD) has proven ineffective in the maneuvering target environment because of its tendency to detonate late at a medium or high TCA when used against a fighter sized target. For this reason the IR fuze must not be used in the ACM environment. If the IR fuze is used in the ACM environment, every effort must be made to fire as close to 0° angle off as possible.

The RF fuze (Mk 15 TDD) is far superior to the IR model in the maneuvering and non-maneuvering environment. The Mk 15 has been modified to operate in the quick reacting 2 pulse mode of operation. Even this fuze encounters problems with late detonation at a high intercept TCA. The details of this fuze are Secret, but, in general, when using the RF fuze, launch conditions which result in a high angle off should be avoided because of reduced kill probability.

Effect of Pursuit Tracking

There is no launch g restriction for the AIM 9D. While high g forces on the launch aircraft will probably lead to a high angle off, this, in itself, should not be interpreted as a launch restriction. The missile may be fired if envelope and tone requirements have been satisfied, regardless of g on the firing aircraft.

In order to obtain a firing tone for the AIM-9D you must boresight the target. Maintaining boresight on a maneuvering target rapidly leads to the attacking aircraft flying inside the prescribed angle off/R_{min} limitations. This implies learning to acquire the tone and fire in the minimum amount of time before angle off or R_{min} limits are exceeded, as illustrated in figure 1–71.

Field of View

In a visual environment the fixed gunsight is used as a reference for missile firing. The AIM-9D has a seeker field of view of 2.5°/44 mils. In 1g flight, when both the missile and gunsight are boresighted properly, the 5-mil null will be centered on the fixed pipper. A check for boresight error should be made on another aircraft prior to entering the combat area. Each missile should be checked individually and deviations noted. During maneuvering flight, missile boresight will precess down the fixed gunsight as a function of turn rate. In low altitude, high speed, and high g flight, this precession will displace the center of the 44-mil field of view down the gunsight 10 to 15 mils.

Firing

The missile can be fired with the target anywhere within the 44-mil field of view. As the pickle is pushed, the seeker unit is uncaged and immediately precesses to center the target in the null. This will result in a reduction or loss of tone, not because it is no longer

Launch G-Pursuit Tracking Effect on Firing AIM-9D

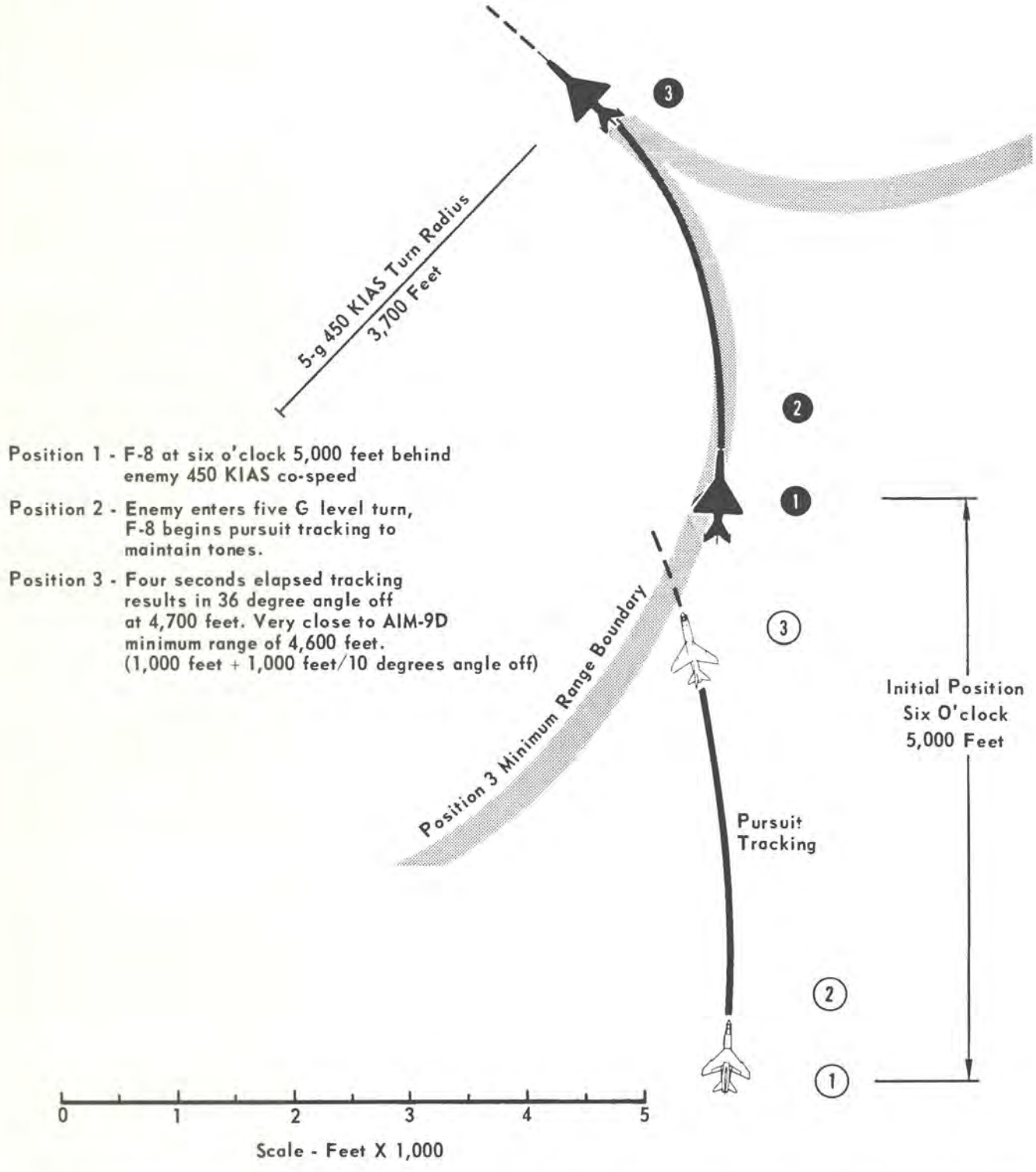


Figure 1–71

seeing the target, but because it is tracking in the null. To give the missile the best chance for success, the target should be as close to the null as possible but with good solid tone at the time of firing. Do not fire without tone, thinking you are in the null. If you are in the null, this would result in good guidance; however, the lack of tone you attribute to the null may actually be the result of a missile or aircraft malfunction. See figure 1–71A.

The beneficial effects of firing with as much lead as possible within the missile field of view are negligible, and the risk of losing the target off the field of view during high g combat maneuvering is great. Since the seeker boresights the target as soon as the stores release switch is depressed, the only advantage of having used lead within the field of view is that of giving the missile a maximum of 1.25° (22 mils) of aerodynamic lead. This will not aid missile performance.

Tracking

When firing the 9D, there is no tracking time necessary. In fact, if too much time is spent tracking the target, the envelope will be overflown as mentioned in the effects of pursuit tracking. The only firing requirements are that the aircraft be inside the firing envelope with a solid tone. It is good practice to continue to boresight the target until the missile fires.

1 Mile Method

R_{min}, R_{max}, and angle off limitations have defined the basic launch envelope. The problem then lies in determining when you are inside it. Statistics have shown that most missiles which have been launched outside the missile envelope have been launched at ranges closer than R_{min}. Studies have shown that our most difficult problem is accurate range determination. In controlled tests, visual estimations of range by qualified pilots were shown to be consistently in error by 50 to 200%.

Angle off is also difficult to determine accurately. Experimentation has shown that estimates to within 15° of actual angle off are the best that can be expected of even the most qualified pilots. For purposes of visual estimation it is recommended that every effort be made to fire at what is estimated to be within 40° angle off.

Target to Null Relationship

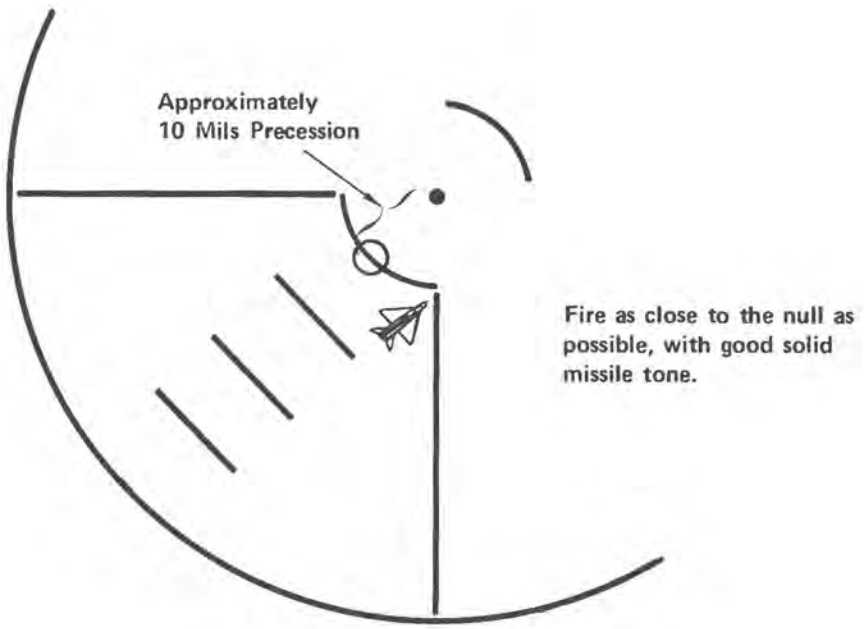
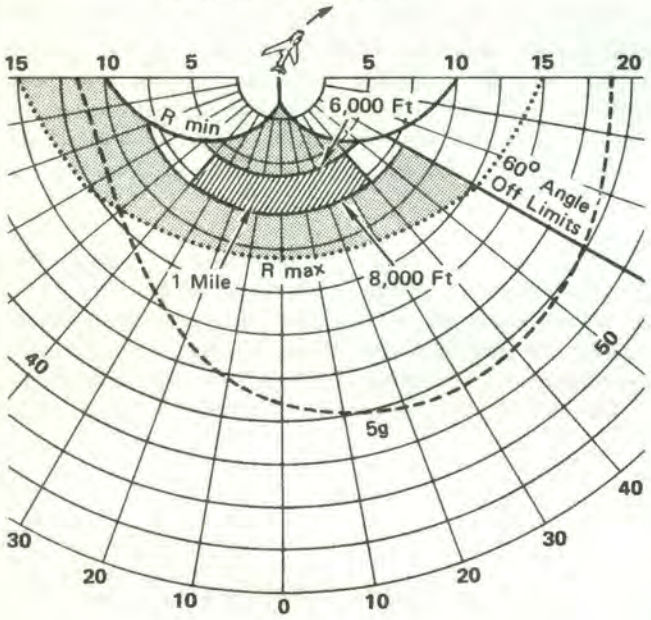


Figure 1–71A

This will ensure that firing will probably occur within the 60° recommended limit for angle off. The 1-mile range therefore extends to 40° either side of the targets tail and is shown within the cross-hatched area in figure 1–71B.



NOTE

1. 1 mile method illustrated by cross-hatched area.
2. Full use of envelope allowed by recognizing and utilizing deviations from from 1 mile method.

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Figure 1–71B. 1–Mile Method Envelope

The 1-mile method is an attempt to give the pilot a specific range for which to strive, thus placing him in the "heart of the envelope". This range is sufficiently inside the ACM low altitude launch envelope to the degree that if a reasonable error is made in estimating range or angle off, you will probably still be within the envelope at the time of launch.

If you think in terms of a single range you can translate this into a single sight picture. For example, a MIG-21 is 4.5 mils at 6,000 feet. By studying this sight picture until it is instantly recognized, a pilot can then more readily assess deviation from it. This permits almost instinctive reaction to a maneuvering situation.

The 1-mile method does not deny the pilot the use of the entire envelope, rather it allows him to instinctively maneuver to a range of 1 mile knowing that other ranges can be acceptable under certain conditions. Therefore, while he is considering whether or not his present position is adequate for a shot, he is automatically improving himself by striving for 1 mile.

To use this method successfully, you must immediately be able to recognize the sight picture of threat aircraft at 1 mile (figure 1–71C). The 2-mil fixed pipper is the only reference for visual range estimation.

Background Interference

Background interference from IR energy as reflected by the ground, clouds, or moon can severely degrade the guidance capability of the AIM-9D. When the pilot is confronted with background IR interference, he must maneuver to a position from which he can definitely distinguish the IR signal of the target from that of the background. It is always best to hold the target against a blue sky background when firing, thereby eliminating all background interference. The AIM-9D cannot be successful against a target obscured by clouds. Clouds diffuse IR radiation and the target IR signal will not reach the seeker.

Note

The 9D should not be fired at a target heading into the sun as solar radiation may decoy the missile. Delay firing until the missile is pointed at least 30° away from the sun.

Ripple Firing

Firing more than one missile at a time is not recommended because of the possibility of the second missile guiding on the first. After launching the first missile, the pilot should attempt to maintain a position from which a second missile could be launched if required. Shoot, look, shoot.

Visual Reference for 1-Mile Method

NOTES

1. **The MIG-21 has a wingspread of 27 feet or 4.5 mils at 1 mile. As depicted above, the size of the MIG-21 aircraft is in proportion to the sight reticle.**
2. **Thorough study of this illustration will assist in recognizing deviations.**



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Figure 1-71C (C)(Gp-4)

SIDEWINDER EXPANDED ACQUISTION MODE (SEAM)

GENERAL

(C) SEAM (AIM-9G) is a development of the AIM-9D Sidewinder heat-seeking missile which permits uncaging the seeker head of the missile and locking on and tracking an IR (Infrared) target while the missile is still mounted on the aircraft launcher. It incorporates the capability of slaving the missile seeker head to the radar antenna after radar lock-on in order than an off-boresight missile lock-on can be achieved. The missile may also lock an IR target independent of radar lock at or near boresight. Once locked-on, the missile will track the target to the gimbal limits of the seeker head.

AIM-9G SEAM MISSILE

(C) (Formerly AIM-9D Mod 2) The SEAM missile has the same outward appearance as the AIM-9D, but has been production-modified to make it compatible with the SEAM system. The basic GCG (Guidance and Control Group) includes only minor modifications which provide a constant reference point to give positive positioning of the seeker head dependent on the missile station selected. the SEAM missile uses the LAU-7A missile launcher with compressed nitrogen coolant, as does the standard AIM-9D, and can be used with either the PP2315 or PP2581 power supply. The airplane fuselage-to-launcher cable and the power supply-to-missile umbilical have also been modified to permit seam control functions. If the SEAM system fails, the missile may be fired as a standard AIM-9D, provided the SEAM system is disabled by placing the SEAM select switch in the OFF position (center).

SEAM ADVANTAGES

(C) The principle advantages realized by the AIM-9G are the ability to maneuver with an IR target off-boresight while retaining missile tone, the capability of firing the missile with the target positioned other than at boresight, and the inherent increase in probability of kill when the missile is fired with lead angle. SEAM provides the capability to fire with lag, however, R_{min} increases by 4,000 to 6,000 feet depending on lag angle and angle off at trigger depression.

MODES OF OPERATION

(U) To accomplish IR target lock-on, two modes of operation are available.

SLAVE Mode

(C) In the SLAVE mode of operation, the missile seeker head is slaved to the radar antenna after full radar lock-on (figure 1–71D). Before radar lock, the missile seeker head remains at boresight. Once angular coincidence between the locked-on radar antenna and the seeker head is achieved and IR signal criteria are satisfied, the seeker head will automatically lock on the target. Subsequent to IR lock, no requirement for radar lock exists and the radar can return to the search mode while retaining SEAM lock. SLAVE mode permits SEAM lock-on with the target if the target is within 30 degrees of the boresight axis.

SCAN Mode

(C) SCAN mode requires that the target be nearly boresighted to fall in the missile field of view. Lock-on in the SCAN mode is achieved with a pilot lock-on or enable switch on the radar control stick, or after AFC 553, with enable switch on either radar control stick or throttle.

SYSTEM OPERATION

(U) Cockpit controls and displays of the SEAM system are illustrated in figure 1-69A.

Double-D SCAN Pattern

(C) To facilitate SEAM lock-on in both SLAVE and SCAN modes, the seeker head field of view has been increased from 2.5 degrees (basic AIM-9D optical field of view) to 7.5 degrees. The missile seeker head is driven in a double-D scan pattern (figure 1-71E) and it takes approximately 4 seconds to complete the double-D pattern. In the SCAN mode, the double-D pattern is superimposed at boresight along the missile longitudinal axis; while in SLAVE, it is superimposed on the line of sight to the radar locked-on target. The double-D scan negates seeker head to antenna slaving errors in SLAVE mode and also increases the capability to lock the IR target at or near boresight in SCAN mode.

Chop Tone

(C) The double-D scan pattern gives rise to a distinctive "chop" tone. As the 2.5-degree cone of the seeker head moves completely around the double-D pattern, it sees an IR target in the 7.5-degree cone at least once. For a target oriented on the periphery of the double-D scan pattern, the seeker head sees IR energy once every 4 seconds and transmits the normal AIM-9D 1,500-cps tone to the pilot's headset. For a target directly at missile boresight, the tone will occur twice during each scan pattern or at 2-second intervals. Other orientations of the target with respect to the scan pattern will cause the chop tone interval to vary. The chop tone variations are shown in figure 1-71F.

a. In the SCAN mode of operation, the pilot can initiate lock-on when he holds his desired target within the 7.5-degree cone at or near boresight and hears the chop tone.

b. In SLAVE mode, chop tone will probably not be heard because of the automatic lock feature.

Double-D Lock-On Logic

(C) When lock-on is attempted from the SCAN mode, the logic in the SEAM system permits the double-D scan pattern to continue for one full pattern (up to 4 seconds) in the event lock-on is not achieved immediately after the pilot's lock-on switch is depressed. This permits lock-on with one switch depression, despite missing the target on the initial pattern sweep during which lock-on is attempted.

SEAM Lock-On

(C) SEAM lock-on will occur in the SLAVE or SCAN mode when an IR target of sufficient energy is seen by the seeker head. The requirement exists that a 3 : 1 (three to one) signal to noise ratio be satisfied for effecting lock-on. That is, the desired IR target must provide three times more IR energy than the general background seen by the missile and must create the necessary audio signal for lock-on.

Chirp Tone

(C) After SEAM lock-on, the missile head seeks the null. Since the null provides no tone to the pilot, there is no means for ascertaining a lock-on with the seeker head at the null. To ensure a tone, a small error signal is generated which drives the missile head away from the null once every second causing the 1,500-cps tone to be heard. The resulting one cps "chirp" tone assures the pilot he is locked-on a point source IR target such as a tailpipe rather than a larger general background such as a cloud. If the SEAM missile is locked-on to a background target, the seeker head will attempt to track and will not null out. Therefore, no error signal will be generated and the chirp tone will not be heard. Additionally, when the seeker head is saturated by IR signal due to hot targets or close ranges, the null is flooded and chirp is not heard. Finally, when a line of sight rate is established between the target and the locked-on missile during maneuvers, a head tracking solution is generated by a tracking ring of the seeker head (outside the null) and the error signal is not applied. As long as the line of sight rate continues, the chirp tone will not be heard.

SEAM Operation in Slave Mode

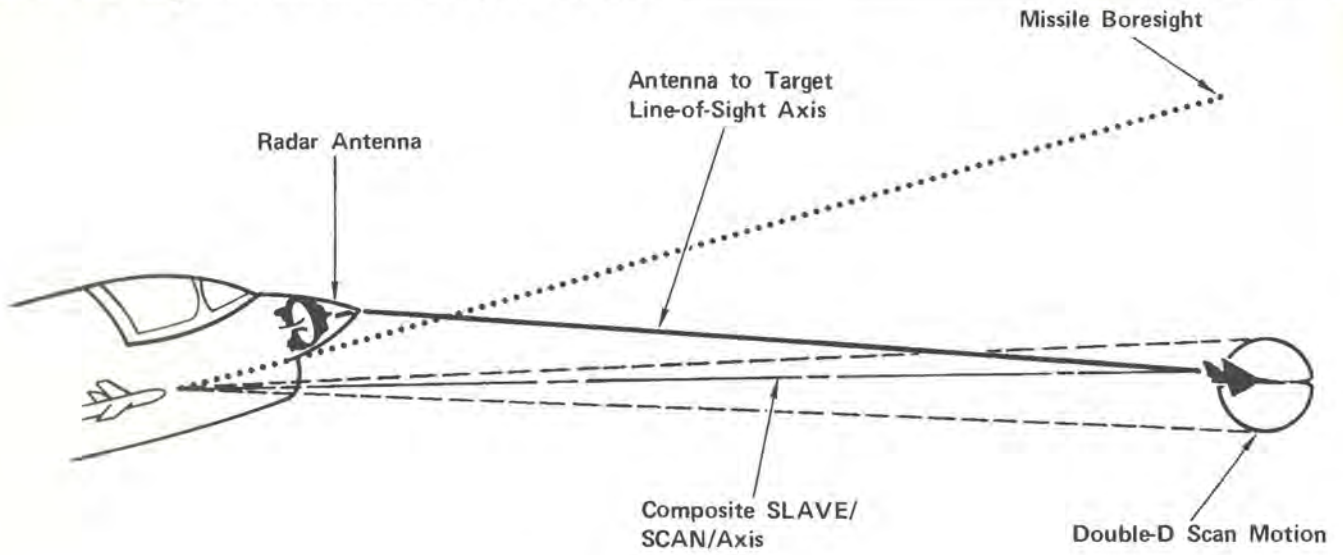


Figure 1-71D (C)

SEAM Break Lock

(U) SEAM break lock is accomplished in the SCAN mode by:

a. Depressing the pilot's enable switch.

b. Removing the target from the missile field of view by exceeding gimbal limits or fuselage shading.

c. Reducing the level of IR energy seen by the missile below that required to sustain lock.

(U) In the SLAVE mode the break lock is accomplished by:

a. Removing the target from the field of view by exceeding gimbal limits or fuselage shading.

b. Reducing the level of IR energy seen by the missile below that required to sustain lock.

c. Deactivating the SEAM system (turning system OFF) so that the seeker head is caged and returned to boresight.

d. Depressing the pilot's enable switch twice, provided the radar lock has been broken.

SEAM Mode Selector Switch

(U) A three position toggle switch located just forward of the starboard canopy rail selects the mode of operation desired. The upper position, labeled "SLAVE," commands SLAVE mode for use with the radar. The lower position, labeled "SCAN," permits use of SEAM in the SCAN mode. The center or "OFF" position deactivates SEAM and causes the missile to be used as a standard AIM-9D.

Pilot Lock-On Button or Enable Switch

(U) The pilot enable switch, located on the radar control stick (after AFC 553, one is also on the throttle), is a momentary ground switch which enables the pilot to lock-on an IR target or break lock while operating in the SCAN mode. In the SLAVE mode, SEAM lock-on is automatic. If the radar lock is broken, depressing the pilot's enable switch twice breaks the SEAM lock.

SEAM Lock Light

(U) An amber lock-on light located on the armament pedestal with SEAM engraved on its lens illuminates when the SEAM missile is locked on an IR source (not necessarily the desired target). After incorporation of AFC 535, an amber light is located on the top of the Sidewinder ranging

Double-D Scan Pattern

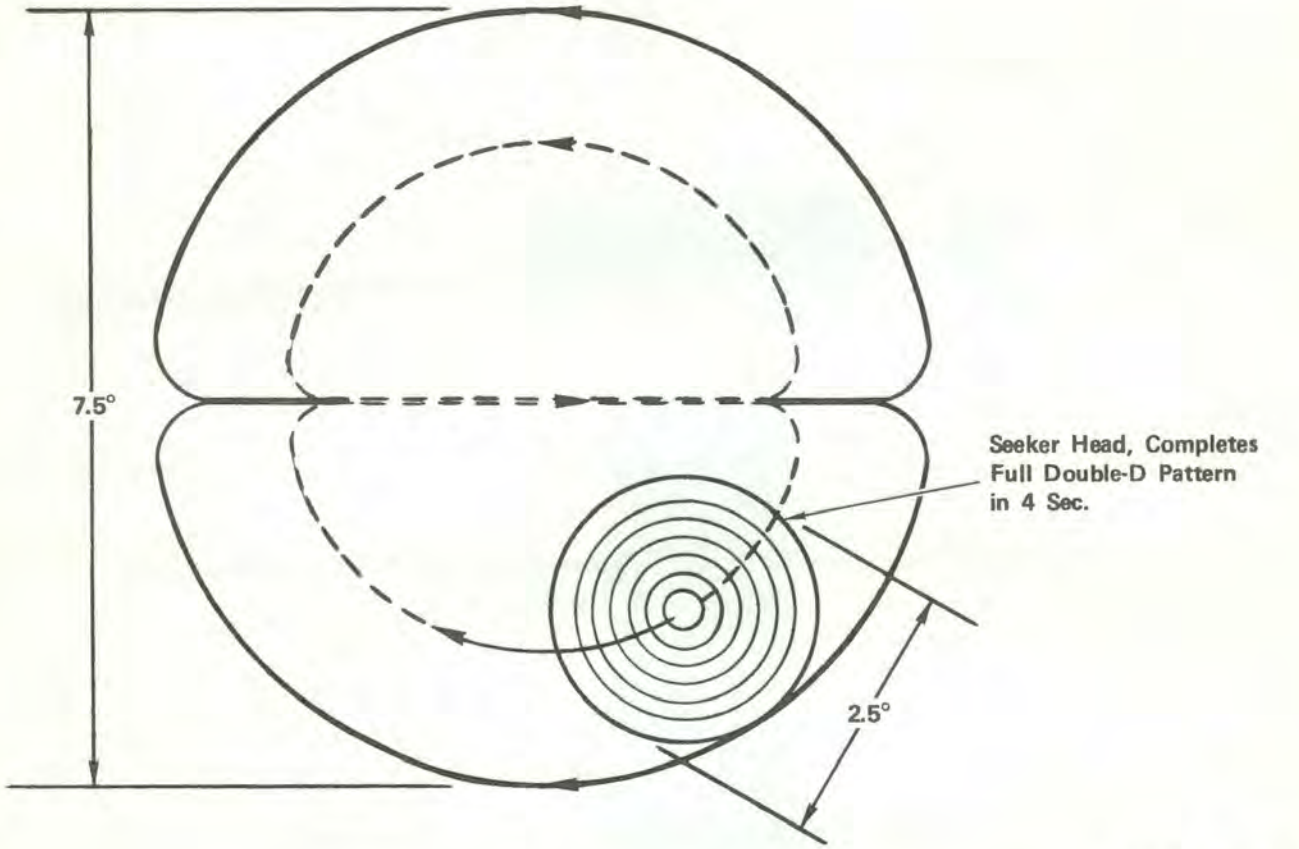


Figure 1-71E (C)

meter, which also indicates SEAM lock-on. All other missile controls for selecting, cooling, controlling audio volume, and arming and firing the AIM-9G remain unchanged from the standard AIM-9D.

AN/ASA-63 SEAM Programmer

(U) The heart of the SEAM system is the AN/ASA-63 programmer. It is a shoebox-sized, transistorized, electro-mechanical unit weighing approximately 13 pounds and installed with two wingnut fasteners to a mounting platform in the port speed brake well.

SEAM SYSTEM GROUND CHECK

(U) Figure 1-71G provides a recap of ground check which should be used to determine the preflight status of the SEAM system. The pilot in the cockpit and a man on deck can conduct a ground check of installed SEAM missiles to determine whether the system will function when airborne. Missile coolant is turned on, the desired station is selected, and audio level is adjusted. Then, with appropriate signals between the cockpit and the ground, the following checks are made:

SEAM OFF Tone Check

(U) The SEAM mode selector switch is placed in the OFF position and a tone check is made with an authorized flashlight as with a standard AIM-9D.

SEAM Scan Pattern Check

(U) SCAN is selected in the cockpit and the ground crewman visually checks that the missile seeker head is describing the double-D pattern. The pilot can also visually ascertain this from the cockpit in the daytime. At night the ground crewman must shine his flashlight at the edge of the

Chop Tone Variation

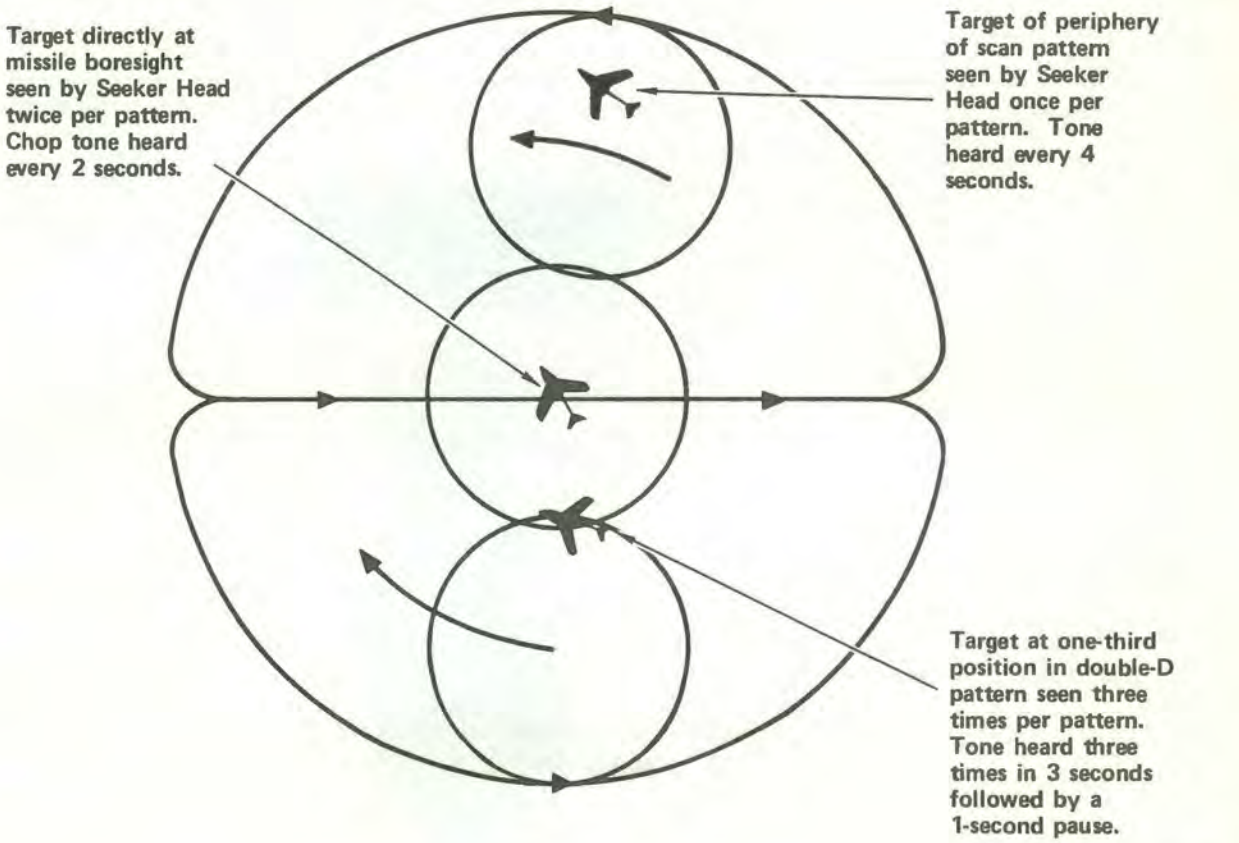


Figure 1-71F (C)

ground glass dome of the missile so that light is reflected from the reflector dish surrounding the seeker head to determine that the double-D pattern is being generated.

Chop Tone Check (SCAN Mode)

(C) The ground crewman steadily holds his flashlight near boresight at a distance of 6 or 7 feet and the pilot listens for the distinctive chop tone. This distance will provide good tones and also keeps the crewman clear of the aircraft intake. With the flashlight at boresight, the tone will be heard once approximately every 2 seconds. The crewman, on signal, then raises or lowers his flashlight until the pilot hears the chop tone once in approximately 4 seconds. The SEAM SCAN PATTERN CHECK and the CHOP TONE CHECK determine that the double-D is being properly generated.

SCAN Mode Lock-On Check

(C) With the ground crewman holding the flashlight near boresight, the pilot attempts lock-on by actuating the enable switch once. The SEAM system will cause the missile to uncage and to lock on the flashlight with resulting illumination of the SEAM lock light. If lock-on is not achieved immediately, a maximum of 4 seconds should elapse before the seeker head sees the flashlight again and locks on. After 4 seconds without a lock-on, the enable switch should be depressed again to reattempt lock-on. After lock-on, the tone will most likely be steady because of seeker head saturation at the distance being used.

SEAM Lock-On Tracking Check

(C) With the SEAM system locked-on, the ground crewman draws the missile seeker head off boresight while continuing

SEAM System Ground Check



SEAM SYSTEM GROUND CHECK	
CHECK	**PROCEDURE**
Standard Missile	Tone checked with authorized flashlight * as with standard AIM-9D (SEAM OFF).
Scan Pattern	Missile seeker head visually observed to describe double-D pattern.
Chop Tone	Pilot listens for scan pattern chop tone while flashlight held in missile field of view.
SCAN Mode Lock-on	Pilot locks-on flashlight signal by actuating enable switch.
SEAM Tracking	Flashlight moved off missile axis. Seeker head follows to gimbal limits.
SEAM Break Lock	SEAM lock broken by: (1) Exceeding gimbal limits (2) Depressing enable switch (3) Turning SEAM to OFF
Chirp Tone	Flashlight moved to sufficient distance from locked-on missile for pilot to hear chirp tone.

*Flashlight with clear, flat glass lens

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Figure 1-71G (U)

to point the flashlight directly at the missile head. In daylight the head is seen to follow the flashlight. The pilot continues to hear tone and see the SEAM light. The ground crewman slowly moves the flashlight near the gimbal limits of the seeker head (40 degrees off axis) to ensure that the missile tracks to its limits.

Break Lock Check Exceeding Gimbal Limits

(C) The ground crewman moves the flashlight beyond the gimbal limits of the missile and the pilot loses tone. The SEAM light may remain on for as much as 4 or 5 seconds before extinguishing because of amplifier saturation. As the light goes out, the missile head returns to boresight and the scan pattern starts again.

Break Lock Check with Enable Switch (SCAN Mode)

(C) The ground crewman realigns the flashlight near boresight and the pilot again commands lock-on. After lock-on, the flashlight is moved off boresight and the pilot depresses the enable switch to break lock. The seeker head will return to boresight and scan will start, tone will be lost, and the SEAM light will go out immediately without the delay caused by amplifier saturation.

Chirp Tone Check

(U) The ground crewman realigns the flashlight at boresight and the pilot again commands lock-on. The pilot hears a steady, saturated tone. The ground crewman then moves the flashlight away from the missile and off axis, being careful to avoid the aircraft intake and other hazards, to a distance of 20 or 30 feet. (This check should not be conducted near the intake with the aircraft engine running.) At this distance, depending on flashlight strength, the pilot will hear the chirp tone resulting from the error signal. The SEAM light will blink in unison with the chirp tone.

SEAM Disabling Check

(U) The ground crewman draws the locked-on seeker head off axis again and the pilot turns SEAM to OFF. The tone will cease and the SEAM light will go out. The ground crewman will then visually observe that the seeker head is boresighted and the double-D pattern has ceased.

(U) When the foregoing steps are followed for each SEAM missile carried, the SEAM system ground checks are completed. The performance of all the functions has been qualitatively checked except for SLAVE mode. These checks can be made as postmaintenance checks on the AN/ASA-63 programmer or the launchers/missile system, or as poststart checks by the pilot incident to flight. It is recognized that all of the above checks may not be practicable in the carrier deck environment but should be attempted if possible.

SEAM SYSTEM AIRBORNE CHECK

(U) Figure 1-71H provides a recap of the airborne checks required to determine the operational status of the SEAM system. Once airborne, the SEAM system can be operated against an aircraft target to perform the same checks that were conducted on the ground. Care should be taken to double check that master armament switch is in the OFF position.

Standard AIM-9D Missile Tone Checks

(C) From a trail position, the pilot deselects SEAM and checks for the 1,500-cps missile tone at boresight. By moving the aircraft nose about, he can detect missile null and also identify the increased 2,250-cps tone associated with the narrow (2 mil wide) intercept arm ring at the periphery of the seeker head. The intercept arm ring gives no guidance commands and in fact has no function, but it does identify the outer boundary of the seeker head. The pilot hears intercept arm passage as a rapid, high squeal as compared to the normal Sidewinder growl.

Chop Tone and Double-D Pattern Check

(C) The pilot then selects SCAN mode and at a range of his choosing (preferably near 1 mile) listens for the distinctive chop tone associated with the double-D pattern. Frequency of tone occurence varies with the orientation of the target with respect to missile boresight. The intercept arm ring squeal may be heard with each tone growl as the seeker head traverses its pattern.

SCAN Mode Lock-On Check

(C) SEAM lock-on in the SCAN mode is attempted by depressing the enable switch when tone is heard. The 4-second (maximum) delay exists if first sweep lock-on is missed. At the end of 4 seconds, the logic in the programmer returns the system to normal SCAN. If the enable switch is depressed within the 4 seconds but before lock-on, the logic in the programmer will return to SCAN commands and lock-on will not occur.

SCAN Mode Break Lock Checks

(U) With lock-on achieved, a solid or chirp tone will be heard by the pilot depending on target range and IR signal strength. The head of the missile should then be drawn off axis by maneuvering the aircraft to ascertain missile track capability. In a series of locked-on, off-axis situations lock should be broken by each of the following:

a. Depressing the enable switch.

b. Turning the SEAM selector to OFF.

c. Exceeding gimbal limits or shading the missile.

Chirp Tone Variation Checks

(U) SEAM lock-on should again be acquired and the target range opened, closed, and opened again so that the tone goes to chirp, becomes solid at saturation, and then chirps again. The target should be instructed to vary its power setting from idle through military to afterburner (if available). The variation in tones from chirp to saturated gives an indication of the response of the SEAM system to variation in IR energy level.

Check of Maneuvering Tone Changes

(U) The target should be locked and instructed to maneuver so that seeker head to target line of sight angular rates can be created. As line of sight rates are established, the chirp tone will disappear and the tone will become solid. Since the line of sight rate requires a tracking correction, the error signal is not generated. When maneuvers are stopped and the seeker head line of sight again becomes static, the chirp tone starts.

SLAVE Mode Lock-On Checks

(C) SLAVE mode can be checked by selecting SLAVE on the SEAM mode selector switch and locking on a target off boresight with the aircraft radar. The radar target should first be held at azimuth or elevation angles in excess of 30 degrees so that no missile tone is heard. The seeker head of the missile is being aligned angularly with the radar antenna but is stopped short of its own gimbal limits. The angle to the target should then be reduced to less than 30 degrees. Missile tone will be heard as lock-on is automatically achieved. Once locked-on, the SEAM system performs identically to SCAN mode lock-on except that lock cannot be broken with the enable switch.

SLAVE Mode Radar Break Lock Check

(U) With SLAVE mode lock achieved, radar lock should be broken to ensure that SEAM lock is held. Depress pilot's enable switch twice to break SLAVE lock-on.

SEAM System Airborne Check

SEAM SYSTEM AIRBORNE CHECK

CHECK	PROCEDURE
Standard Missile	Tone checked with SEAM system OFF.
Chop Tone	Pilot listens for chop tone. Target reoriented about boresight to determine double-D pattern.
SCAN Mode Lock-on	Pilot locks-on target by depressing enable switch.
SEAM Tracking	While locked-on, airplane maneuvered to draw seeker head off axis.
Chirp Tone	Range to target, power setting of target varied to obtain chirp/saturated tone. Target maneuvered to establish line of sight rate so chirp tone is lost.
Scan Mode Break Lock	(1) Depressing enable switch (2) Turning SEAM to OFF (3) Exceeding gimbal limits (4) Shading seeker head with airplane fuselage
SLAVE Mode Lock-on	With radar lock-on, SLAVE mode selected to achieve SEAM lock-on.
SLAVE Mode Break Lock	(1) With radar lock-on broken, depress enable switch twice to break SEAM lock. (2) Turning SEAM to OFF (3) Exceeding gimbal limits (4) Shading seeker head with airplane fuselage

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Figure 1-71H (U)

Check for Proper Roll Resolver Setting

(U) In the event a SLAVE mode lock cannot be obtained after a radar lock but the system works properly in the SCAN mode, the roll resolvers in the ASA-63 programmer may be improperly set for the fuselage pylon configuration. Use of SLAVE mode should not be attempted in this event.

(U) Again it is recognized that all of the foregoing checks may not be feasible in all operating environments, but they are recommended as optimum checks. As a minimum, good tone checks should be obtained.

SEAM SYSTEM LIMITATIONS

(C) In addition to checking the system, completion of the ground and airborne checks provides a firm basis for understanding the total operation of the SEAM system, but does not necessarily provide an insight into the limitations of the system. The SEAM system retains the same tracking limitations as the AIM-9D. In fact, once locked on the target, the missile performs as if it were in flight rather than attached to the aircraft, except that SEAM break lock will occur when target IR energy drops below the SEAM lock-on threshold level.

Missile Tracking Limitations

(C) The seeker head of the missile is capable of tracking line of sight rates up to a nominal 12 degrees per second. The same capability exists whether the missile is in flight or mounted on the aircraft launcher. The tracking rate capability is dependent on the signal strength, with increasing rate for strong IR sources and diminishing rate for weak sources. The result is that SEAM lock will be broken in

heavy maneuvering situations when the maximum line of sight rate is exceeded or when the IR signal becomes weak due to power changes, plume shifting, or structural blanking (shielding).

Seeker Head Offset Limitations

(C) The missile possesses its greatest tracking capability when the seeker head is at or near boresight. As head angle increases, the missile capability to track high line of sight rates decreases. Although the missile can be fired with the seeker head deflected to its gimbal limits, such a shot would in all probability fail because the seeker head would hit the gimbals and tumble while trying to track or would not be able to follow even low line of sight rates. Additionally the 0.5-second delay that exists on missile launch after leaving the launcher, before canard guidance, will cause a missile-to-target line of sight rate that will exceed missile capability even though there is no firing aircraft-to-target line of sight rate. Thus a missile firing should not be attempted near the seeker head gimbal limits.

False Target Lock-On, Shift Lock, and Lock-On Ambiguity

(C) The SEAM missile reacts not only to the level of IR energy for lock-on, but it also has the capability of discriminating a target from its background. If the target criterion discussed under SEAM Lock-On is satisfied, lock-on can be achieved. However, care must be exercised to ensure that the missile is not being deceived by its environment during or after lock-on.

a. False Lock-On. A bright cloud background of any size, but in the field of view of the seeker head, may be able to satisfy both threshold level and the 3 : 1 discrimination criteria because of hot spots. Any target in the seeker head field of view could result in the same false lock.

b. Shift Lock. Once the SEAM system has locked on the desired target, the target is held within the narrow 2.5-degree optical field of view of the seeker head. However, any IR source within that field of view, along the line of sight to the target, which satisfies lock-on criteria will be equally acceptable for lock-on and shift lock can occur. Stronger IR sources (such as the sun or an afterburner) in the line of sight will be most likely to cause shift lock, but isolated cases of SEAM lock shifting to bright cloud backgrounds may also occur.

c. Lock-On Ambiguity. After lock-on there is no positive indication of seeker head position available to the pilot. If a false lock-on has occurred, the seeker head may be pointed in any direction. The SEAM lock light tells him the system is no longer scanning but is locked-on an IR source. It does not indicate to what source the system has responded. The pilot must interpret the tones in his headset for this final determination. The presence of chirp tone indicates a point source lock-on. A solid tone might mean a point source which saturates the seeker head, a cloud background, or in a maneuvering environment the existance of a line of sight rate. In most cases of point source lock-on, the tone will chirp at some early point after lock-on. The pilot must be keenly aware of the various tone characteristics and the way they change in order to recognize possible ambiguous lock situations.

LAU-7A Launcher Power Supply (PP2581) Restrictions

(U) Both the PP2315 and PP2581 power supplies are compatible with the SEAM system. However, because of differences in missile identification methods, they do not respond identically on firing command.

Note

The PP2581 power supply will cause the missile seeker head to be caged if the stores release switch is released before the missile shifts to fire normally, but, if the seeker head is off boresight when the stores release switch is released early, the caging action will most likely cause the missile to lose the IR target and the missile will fail to guide and go ballistic. The PP2315 power supply is not limited by this caging action on any station.

(Interim IAVC 1034 to the SEAM programmer removes the requirement to hold stores release switch until missile launch with PP2481 installed.)

Fuselage Shading of the SEAM Missile

(C) When the line of sight from the seeker head to the target passes through the aircraft fuselage, IR energy is blanked off (or shaded) and the SEAM missile will break lock. The minimum angle at which shading occurs for any of the possible missile stations is 10 degrees for either the left or right single station.

Automatic Lock-On When Selecting SCAN Mode

(C) When an IR target is held near boresight and the SCAN mode is selected, the signal level may be great enough to trigger lock-on automatically. Since this is not necessarily desirable, missile boresight should be directed away from the target when moving the mode selector switch from OFF to SCAN.

TACTICAL APPLICATIONS

(U) In order to take full advantage of SEAM, it is necessary that thorough knowledge of the missile, the system, and their limitations is completely understood. No attempt

should be made to fire the missile in its SEAM modes until the pilot is well versed in the principles and implications of SEAM operation. In particular, he should be trained to recognize the tones and how they vary with the conditions at hand. The operation of the SEAM system gives rise to a number of guidelines for its tactical employment.

SEAM Missile/System Checks

(U) The missile must check out before use with SEAM. If the missile fails to give good tone checks or if coolant failure occurs, do not attempt use of SEAM system. If the SEAM system operational checks fail, the system should be turned OFF and the missile used as a standard AIM-9D. If SLAVE checks fail, SEAM may be implemented in the SCAN mode.

Mode of Lock-On

(C) Once SEAM lock-on has been achieved, the system is independent of the mode from which it was obtained. If the system breaks lock with SCAN mode selected, the seeker head returns to boresight. If the system breaks lock with SLAVE mode selected, the seeker head matches the radar antenna look angle if radar lock is still held. In a multiple target environment, this becomes important if a second radar target was locked-on subsequent to SEAM lock, because the SEAM missile will now try to lock-on the second radar target.

SCAN Mode Lock-On

(C) The pilot should anticipate the target's location in the scan pattern and actuate the enable switch before the seeker head reaches the target because of the possibility of a 4-second (full double-D scan pattern) delay in lock-on. The enable switch should not be depressed a second time until the 4 seconds have elapsed. If confusion arises as to what has been done with the enable switch, the SEAM mode selector switch should be cycled through OFF and back to SCAN. The logic will then be set at SCAN vice lock-on. In all cases, SCAN mode lock-on should be attempted as close to boresight as possible.

(C) SCAN mode will probably be most used in the ACM environment where the target can be brought near boresight. Although automatic lock-on in SLAVE mode is optimum, the present mechanization of the installed radars does not permit positive radar lock in the BAT (Boresight Acquisition Track) mode, but rather results in a high likelihood of altitude line lock-on. An altitude line lock-on will result in either a false SEAM lock-on or no lock-on.

(C) SCAN mode of SEAM lock-on may be particularly important in the air intercept environment under electronic countermeasure conditions where radar lock cannot be maintained and the target is not held visually. With radar search mode, the target can be brought within the 7.5-degree double-D pattern near boresight and SEAM lock-on can be obtained.

SLAVE Mode Lock-On

(C) In order that the best utilization of SLAVE mode be realized, the earliest possible radar lock should be attempted, either from BAT or normal search. This is true during ACM or intercepts. The missile will then lock-on as soon as it sees IR energy and final maneuvering can begin with missile tone. The SLAVE mode has the added advantage presented by the additional look angle of the radar. Even though SEAM break lock will occur at missile gimbal limits, the seeker head will pick up antenna slave signals and be ready to relock when the radar line of sight angle is reduced.

BREAK LOCK

(C) Seam lock-on can be broken at any time by selecting OFF or by depressing the enable switch when SCAN is selected. The break lock delay with IR signal loss (4 to 5 seconds) due to amplifier saturation can be negated by the same methods. Seam lock should be broken whenever uncertainty or ambiguity of lock occurs.

Target Signal Reduction

(C) SEAM break lock should be anticipated whenever the target performs a maneuver that will either reduce IR signal level or possibly blank the signal entirely. As long as the missile is fired in envelope, with good tone and in SEAM, the missile should perform properly. If break lock occurs due to signal loss, SEAM lock-on should be re-attempted or the system deselected, depending on the range and maneuvering dynamics at the time.

SEAM TONES

(C) The distinctive tones that SEAM presents tell the pilot what kind of a target his missile is seeing or is locked-on. His interpretation of the chop and chirp tones tells him whether he has a point source of a false lock-on. A momentary high squeal tells him he may have lost the target through the intercept arm ring and that he has to try locking again, even though he may have a SEAM light (due to break lock delay) and tone of some sort (load background noise). Loss of chirp during maneuvers is expected. Saturated signal is expected when the target selects afterburner or when the range is close.

Note

(U) As with other features of SEAM, if confusion exists as to what the tones are saying, the best course of action is to turn SEAM to OFF and use the basic missile. These factors must be weighed with the tactics at hand.

AMBIGUITY

(C) Since ambiguity of lock-on can occur, as can confusion with tone changes and with lock-on logic in SCAN, the best

recourse in these instances is to deselect SEAM momentarily or leave it OFF until the propitious moment to reselect it. Target ambiguity does not occur often, but firing when it does occur can result in a lost missile if the target was, in fact, a false one.

SHADING

(C) Fuselage shading of the missile varies for the different configurations, but in no case occurs at less than 10 degrees of seeker head angle. The 10 degrees establishes the maximum lead or lag angle for the offside missile during maneuvers. When the target and the firing aircraft maneuver in the same plane, the target disappears under the nose of the firing aircraft at just about 10 degrees; hence, this establishes a visual reference for impending blanking of the missile. In other attitudes, the same offside missile may be able to track very near its gimbal limits without suffering shading. When shading occurs, the missile tone drops to background level and the look angle must be reduced to reacquire the target.

MANEUVERING AND LINE OF SIGHT RATES

(C) With SEAM lock-on established, the missile tone will be heard as long as the missile can see the target and the 12 degree per second (depending on IR signal strength) line of sight rate is not exceeded.

Maneuvering to Achieve Firing Position

(C) With the assurance of a missile tone, it remains for the pilot to maneuver his aircraft to a suitable firing position. The optimum method is to head for the heart of the Sidewinder envelope (1 mile range for almost all conditions), generate lead and fire. Since this is not possible in many tactical situations, he must assess his present angle off and range and then decide if he can fire. In the minimum range situation he will increase his P_k by firing with lead; he will reduce it with lag.

Maneuvering in a Lag Situation

(C) Against a hard maneuvering target, the firing aircraft will find itself lagging the target more often than leading it. Sage advice says "wait" until the target can be boresighted or led. A hasty shot against a maneuvering target while in a lag position will most likely result in a failure of the missile to guide because of the parameters of the shot. The range required for a successful lag shot should permit some other recourse, such as lead. An exception to this last statement occurs when the firing aircraft is in a nose low attitude and cannot bring the nose up to the target. In this case, a lag firing at sufficient range might be the only acceptable solution. With a stabilized 10° of lag, $_{min}$ range increases approximately 4,000 to 6,000 feet from AIM-9D R_{min}. Therefore lag firing should not be attempted because the minimum ranges for which a missile can be fired with lag are great enough so that the firing aircraft can achieve lead, or at least from boresight.

High Line of Sight Rates

(C) During ACM and at close ranges in particular, high line of sight rates will be established and SEAM break lock should be expected. If break lock occurs, the choice should be made immediately between deselecting SEAM or reattempting lock.

Maneuvering to Retain SEAM Lock

(C) Unless a definite tactical advantage exists, maneuvers should not be geared toward retaining SEAM lock, but should be pressed to gain the best possible advantage. If fuselage shading is impending (as during a high yo-yo), SEAM break lock should be accepted and the aircraft flown as the tactics dictate. The missile can always be fired as a standard AIM-9D if the SEAM lock-on cannot be regained and the SEAM select switch is placed in the OFF position.

LEAD

(C) Theoretically the missile can be fired with any lead angle which permits the seeker head to see the target. The previous discussions show that lead should be limited to 10 degrees, which is further amplified in the following paragraphs.

Rapid Changes in Lead

(U) In the dynamic ACM environment, the lead angle may change rapidly because it cannot be sustained. If the missile is fired at a close range which is lead dependent, it may well fail because the lead changes to lag before the missile is launched.

Apparent Lead

(C) The actual lead angle that the missile achieves is reduced by the angle of attack of the aircraft (figure 1-71J). Under high g conditions, the actual lead commanded may well be reduced to near zero or even to lag. If the missile is fired at a range which is lead dependent, the aircraft angle of attack may reduce the lead below an acceptable amount and the missile will fail.

Lead Limits

Reduced Tracking Capability at Large Head Angles

(C) Ten degrees of lead sets an acceptable limit below which the missile has the capability of tracking high line of sight rates.

Multiplicity of Envelopes

(U) By providing the capability of firing the SEAM missile at other than boresight (where basically only one envelope exists) when an envelope exists for each increment of lead or lag, the pilot will become quickly saturated with missile

Degradation of Apparent Lead by Angle of Attack

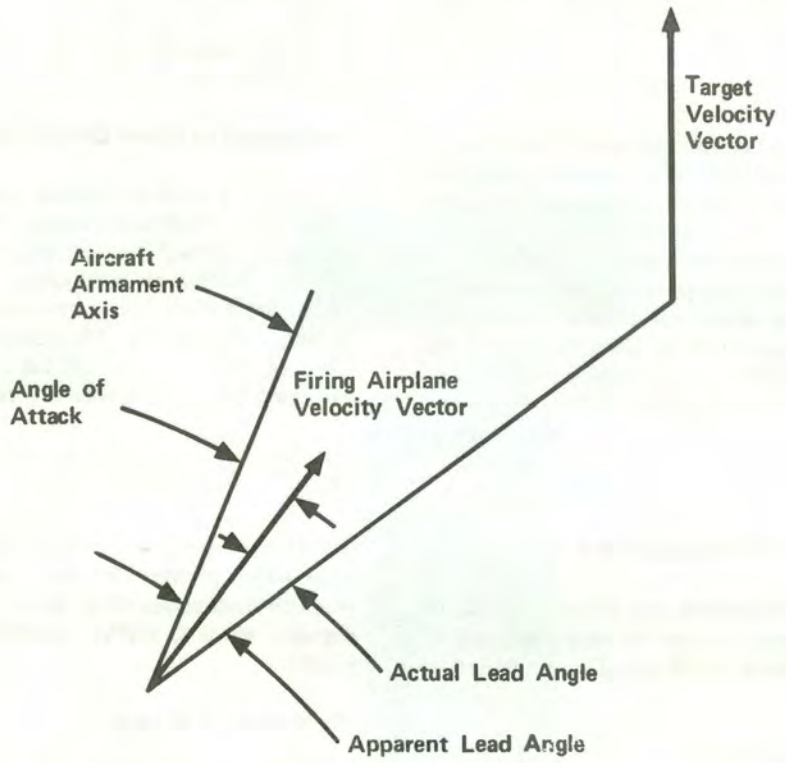


Figure 1-71J (C)

envelopes. Because of the infinite number of firing envelopes, the pilot should be trained to recognize the presently accepted AIM-9D envelope and encouraged to fire with lead when possible.

SEAM MISSILE FIRINGS

(C) There are no changes in firing procedures for SEAM except that the stores release switch must be held down until actual missile launch.

Note

(U) Because pilots are not always certain of the power supply in use, the stores release switch should be held down until actual missile launch.

CONCLUSION

(U) SEAM provides the F-8H/J pilot with a substantial improvement to his Sidewinder weapons system. The SEAM missile is much more than just the Sidewinder which is pointed and fired. The pilot must achieve a level of understanding and training which will permit the system to be used to its full advantage.

AIM-9B AIR-TO-AIR MISSILE

AIM-9B COMPONENT DESCRIPTIONS

(U) The AIM-9B missile consists of six component parts or assemblies: Guidance and Control Section; contact fuze; influence fuze; warhead; motor; and four wing assemblies. The assembled missile is 5 inches in diameter, 111.5 inches in length, and 158 pounds in weight. See figure 1–72.

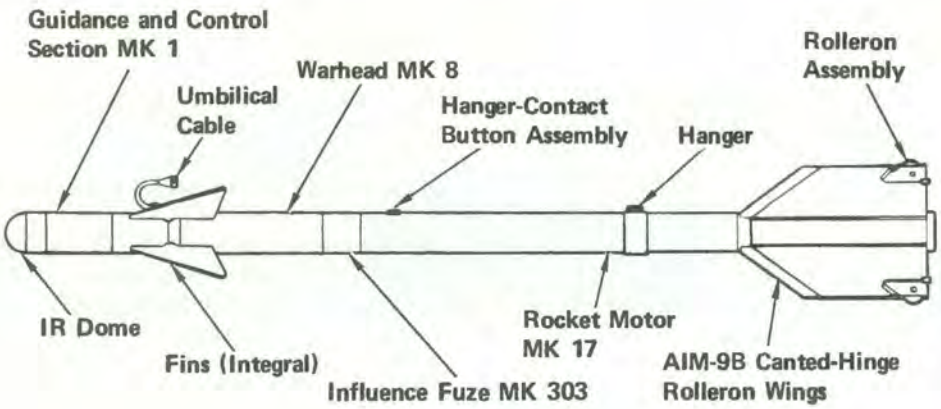
Guidance and Control Section

(U) The forward end of the AIM-9B Guidance and Control Section (G&C) is housed behind a clear Pyrex glass dome. This hemispherical dome provides a window for the gyro-optics IR tracker which is readily visible inside.

(C) Significant specifics of the G&C are: field of view 4 degrees, gyro gimbal angle limits 25 degrees from missile longitudinal axis, and maximum gyro tracking rate set at a nominal 8 to 11 degrees per second, with guidance time limited to 21 seconds by gas generator grain burn time. These parameters are important because they affect the performance capabilities of the AIM-9B and therefore affect tactics. The 4 degree field of view represents a compromise between acquisition capability and seeker sensitivity. Although adequate detection ranges can be obtained against a blue sky background, bright clouds and other highly reflective background such as water, snow, and desert degrace target discrimination. Because of the spectral response of the seeker, the AIM-9B responds primarily to hot metal parts of the engine and is therefore severely limited at high angles off the tail.

(U) These considerations, coupled with a modest airframe maneuvering capability, limit the size of the tactical launch envelope, particularly against maneuvering targets.

AIM-9B Missile



CHARACTERISTICS

Motor Burn Time	–	2.2 Seconds
Thrust	–	3,820 Pounds
Speed	–	1.7 Mach (above launch speed)
Guidance Time	–	21 Seconds
Warhead Type	–	Blast/Fragmentation
Warhead Lethal Radius	–	30 Feet (radius)
Minimum Range	–	3,000 Feet
Turn Capability	–	12G at Sea Level
Field of View	–	70 Mils (4°)
Gimbal Limit	–	25 Degrees
Gyro Tracking Rate	–	8°/Second

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Figure 1–72

Warhead

The warhead for the missile is a blast-fragmentation type weighing 25 pounds. On detonation of the explosive, the steel warhead case is cut into approximately 1,300 fragments. These fragments accelerate rapidly and reach a maximum velocity of 6,000 feet per second in their trajectories and are able to pierce ⅜-inch steel plate at a distance of 30 feet. The fragments are 90% contained in a 15° solid angle extending 360° around the warhead. In addition to the lateral dispersion, the fragments will be thrown forward with missile velocity. Blast damage is an important part of the warhead damage mechanism. This damage is effective to 10 feet distance at sea level, but degrades rapidly with increased altitude. Warhead detonation may be initiated by a contact fuze, influence fuze, or the self-destruct circuit located in the G&C.

Fuzing

The influence fuze is mechanically attached and electrically mated to the forward end of the rocket motor. An explosive booster is threaded to the fuze and projects into the aft end of the warhead. Warhead detonation in a close miss situation is initiated by influence fuze action. The influence fuze for the Sidewinder AIM-9B is an IR sensing device. It has an optical system that "looks" out the windows in the fuze housing at two different look angles. The two look angles provide information which is used to discriminate against false targets. As the missile passes by the target, the IR energy from the engine appears in the first field of view generating a preparatory command pulse in the fuze circuitry. As the missile continues to pass the target, IR energy from the engine is seen in the second field of view and a command of

execution pulse is generated in the fuze circuitry. After a fixed time delay to allow optimum penetration, warhead detonation occurs.

This fuze is optimized for near tail-on attacks in which the intercept trajectory is roughly parallel to the target axis. Launch conditions resulting in high track crossing angles at intercept, such as attained against maneuvering targets, cause a significant degradation of fuze-warhead effectiveness. The influence fuze is mechanically armed during missile acceleration 480 to 840 feet in front of the launching aircraft, and is electrically armed by an acceleration switch at motor burnout, approximately 2,000 to 2,500 feet in front of the launch aircraft.

The contact fuze is mechanically attached and electrically mated to the aft end of the Mk 1 guidance and control section. The contact fuze detonates the warhead when the missile makes positive contact with the target. Mechanical arming of the contact fuze is accomplished in the same manner as for the influence fuze. Electrical arming, however, occurs at umbilical shear. It is this characteristic that places a practical limit of 1,000 feet on minimum range, providing a contact hit is achieved. Since the influence fuze does not become fully armed until motor burnout which occurs at 2,000 to 2,500 feet, any AIM-9B missile fired at less than 2,000 to 2,500 feet range will have contact fuze capability only.

Rocket Motor

WARNING

The NPA must be removed immediately prior to loading. An AIM-9B missile fired on an aircraft with a non-propulsive unit installed can result in loss of the aircraft and life.

The rocket motor utilizes a solid propellant fuel and provides an average of 3,820 pounds of thrust for 2.2 seconds of burning time, boosting the missile to Mach 1.7 above launch speed. Power to the igniter is provided through the aft contact button on the forward hanger. A firing pulse to fire the influence fuze thermal battery is provided through the front contact button on the forward hanger. A nonpropulsive attachment (NPA) attached to the nozzle of an assembled missile neutralizes thrust if the motor is inadvertently ignited.

Wing Assemblies

Four wings with rollerons are mounted on the aft end of the motor for lift and stability. In captive flight the rolleron housing is mechanically caged while the airstream causes the rolleron wheels to rotate at all times. When the missile is launched, the rollerons are uncaged. Gyroscopic action of the spinning wheel produces an aerodynamic force on the housing which counteracts oscillation in pitch and yaw, as well as roll. Wings with straight hinge line rollerons exist which are effective only to counteract roll.

CAUTION

Do not mix straight and canted hinge line rollerons on a missile, as an unbalanced aerodynamic response may result.

Stright hinge wings are normally used for training only. Canted hinge wings are preferred and may require the installation of caging clips to aid the caging pin when carried on certain aircraft stations.

AIM-9B OPERATIONAL APPLICATIONS

The AIM-9B has not demonstrated a capability against a high g maneuvering target. The AIM-9B does have a limited capability against targets maneuvering up to 3g's if launched within 25° angle off. The missile's capability against a maneuvering target is limited because of lambda limit in the guidance and control section plus the aerodynamic capability of the missile. The AIM-9B non-maneuvering launch envelopes are illustrated in figure 1–73.

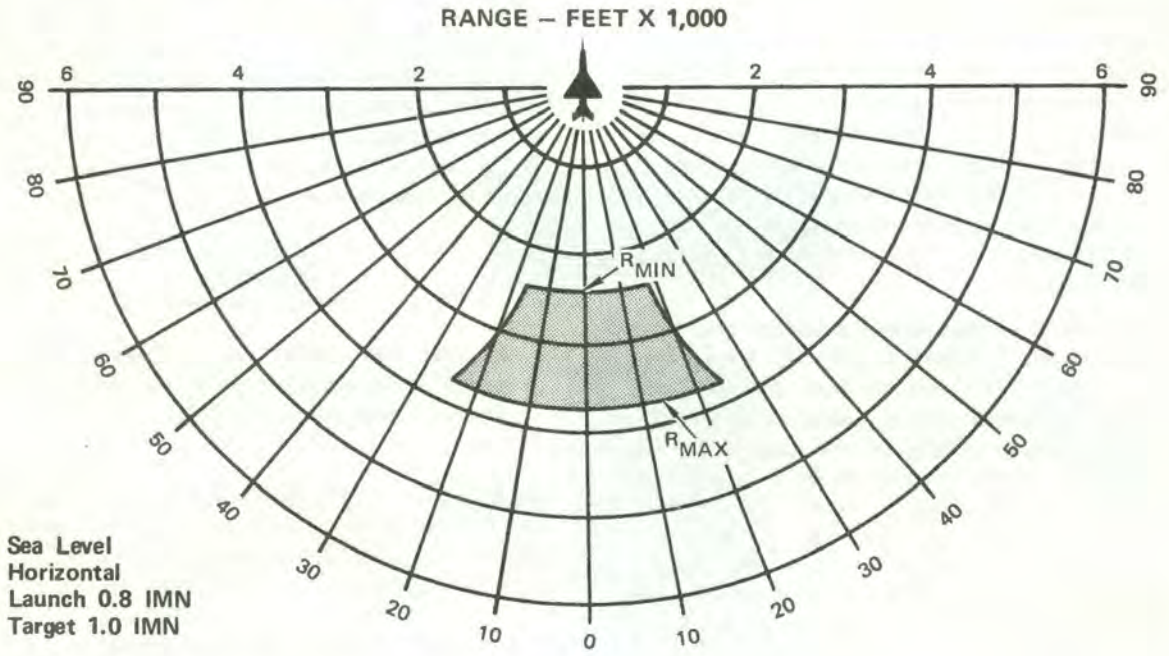
Whenever an AIM-9B is launched at a turning target, it must make an initial correction to assume a collision course. During time of flight as the target continues to turn and as the missile accelerates, progressively greater corrections inside the target radius of turn are required. These effects increase the possibility of exceeding the look-angle (lambda limits) of the missile which results in ballistic flight (figure 1–74).

Note

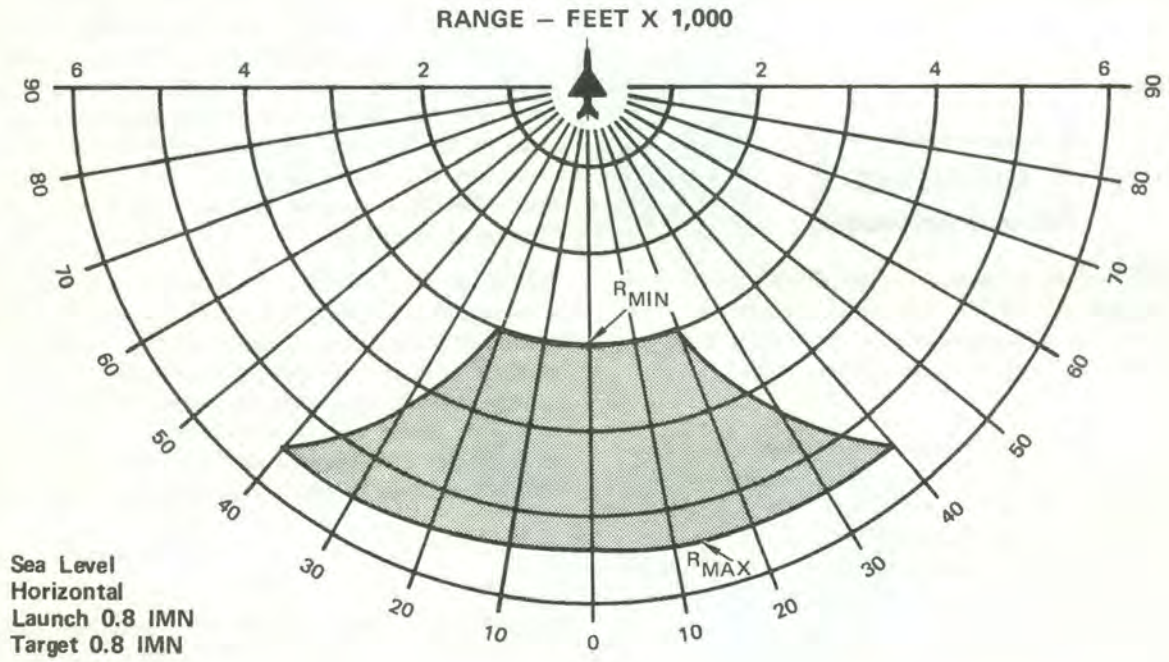
Whenever the AIM-9B is launched at a maneuvering target, every effort should be made to launch as close to a 0° angle off as possible and at midrange. For maximum launch range, see figure 1–75.

AIM-9B Launch Envelopes

NON-MANEUVERING TARGET



Sea Level
Horizontal
Launch 0.8 IMN
Target 1.0 IMN



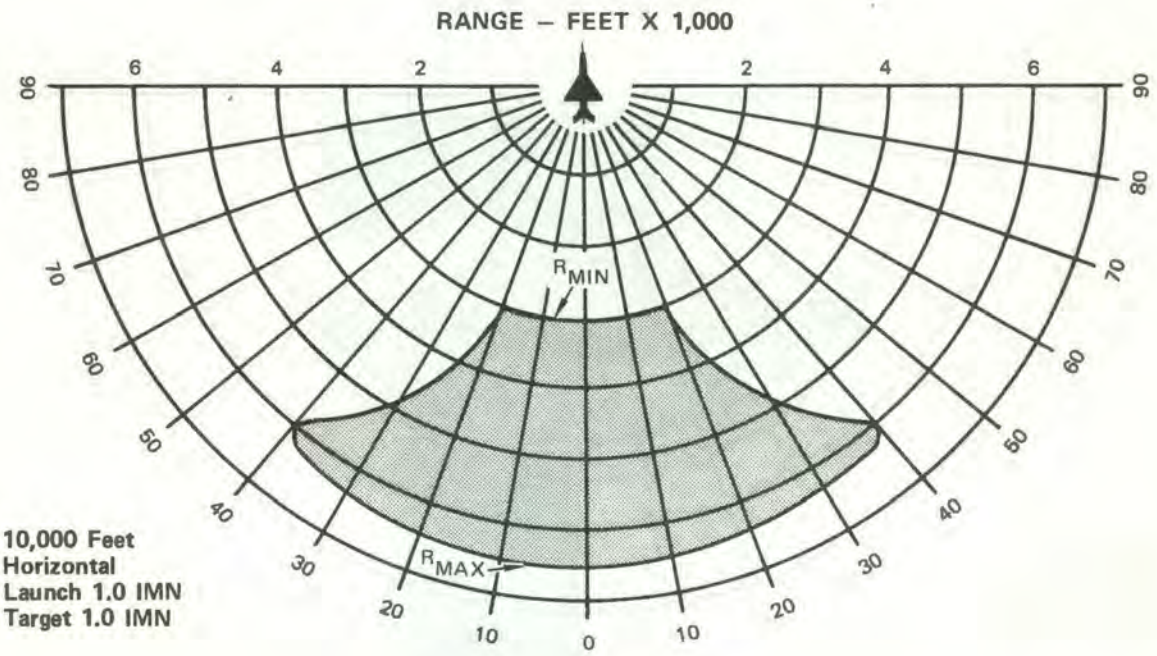
Sea Level
Horizontal
Launch 0.8 IMN
Target 0.8 IMN

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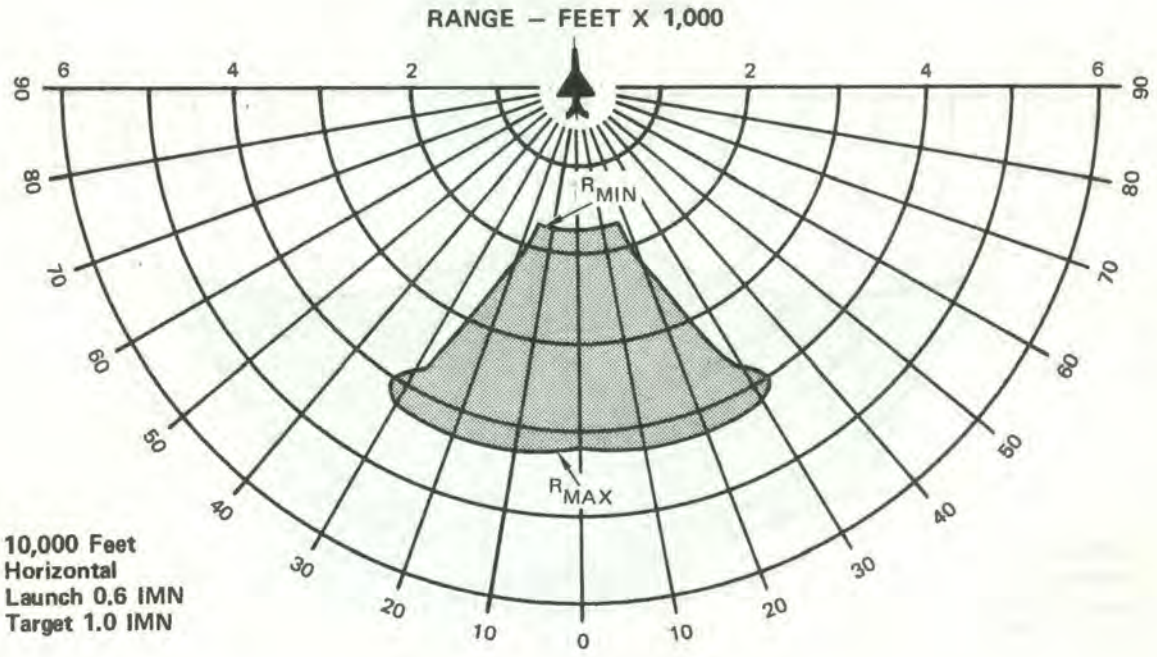
Figure 1-73 (C)(Gp-4) (Sheet 1)

AIM-9B Launch Envelopes

NON-MANEUVERING TARGET



10,000 Feet
Horizontal
Launch 1.0 IMN
Target 1.0 IMN



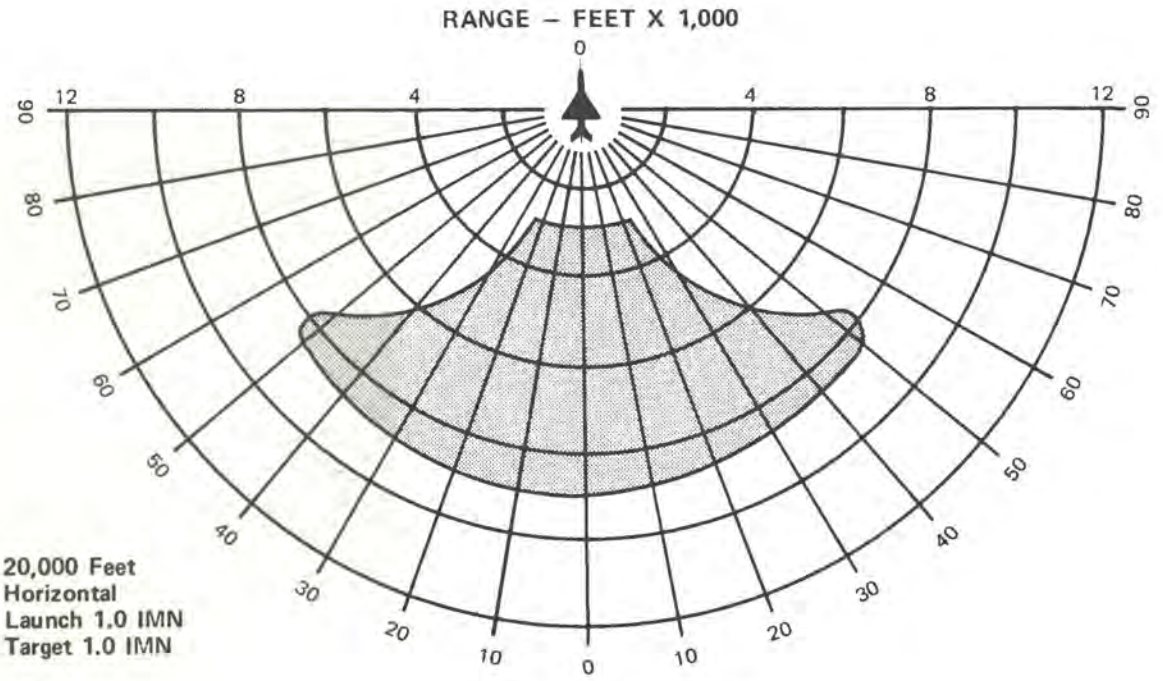
10,000 Feet
Horizontal
Launch 0.6 IMN
Target 1.0 IMN

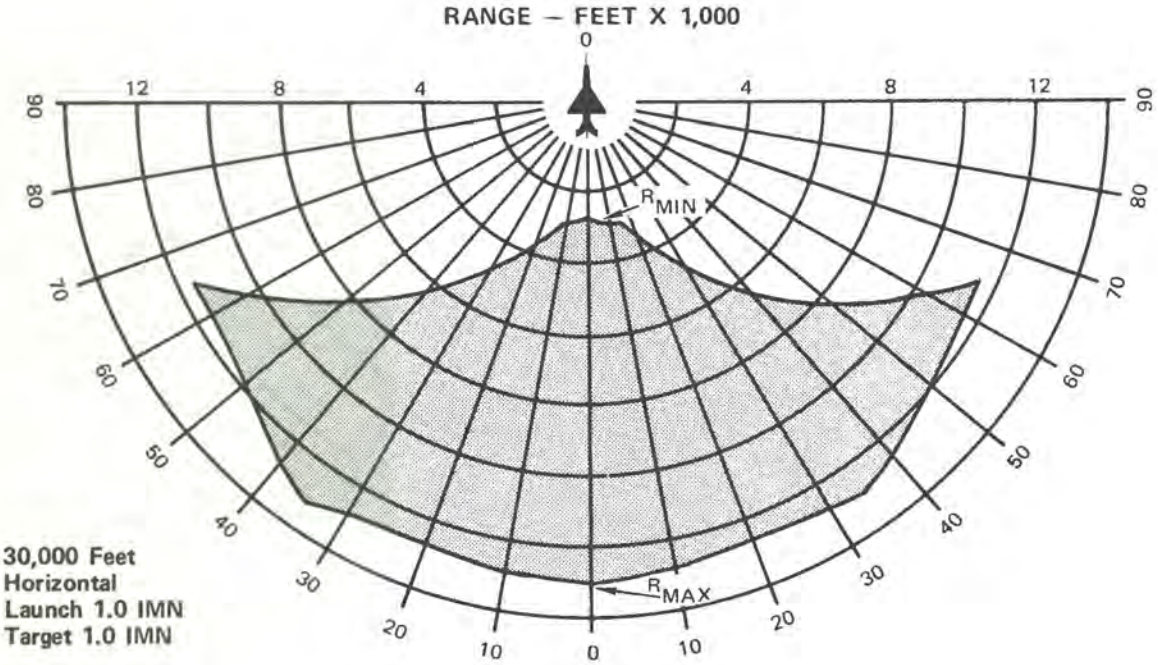
AZ-119(2)-3-69

Figure 1–73 (Sheet 2)

AIM-9B Launch Envelopes

NON-MANEUVERING TARGET





AZ-119(3)-3-69

Figure 1–73 (Sheet 3)

AIM-9B Envelope Parameters

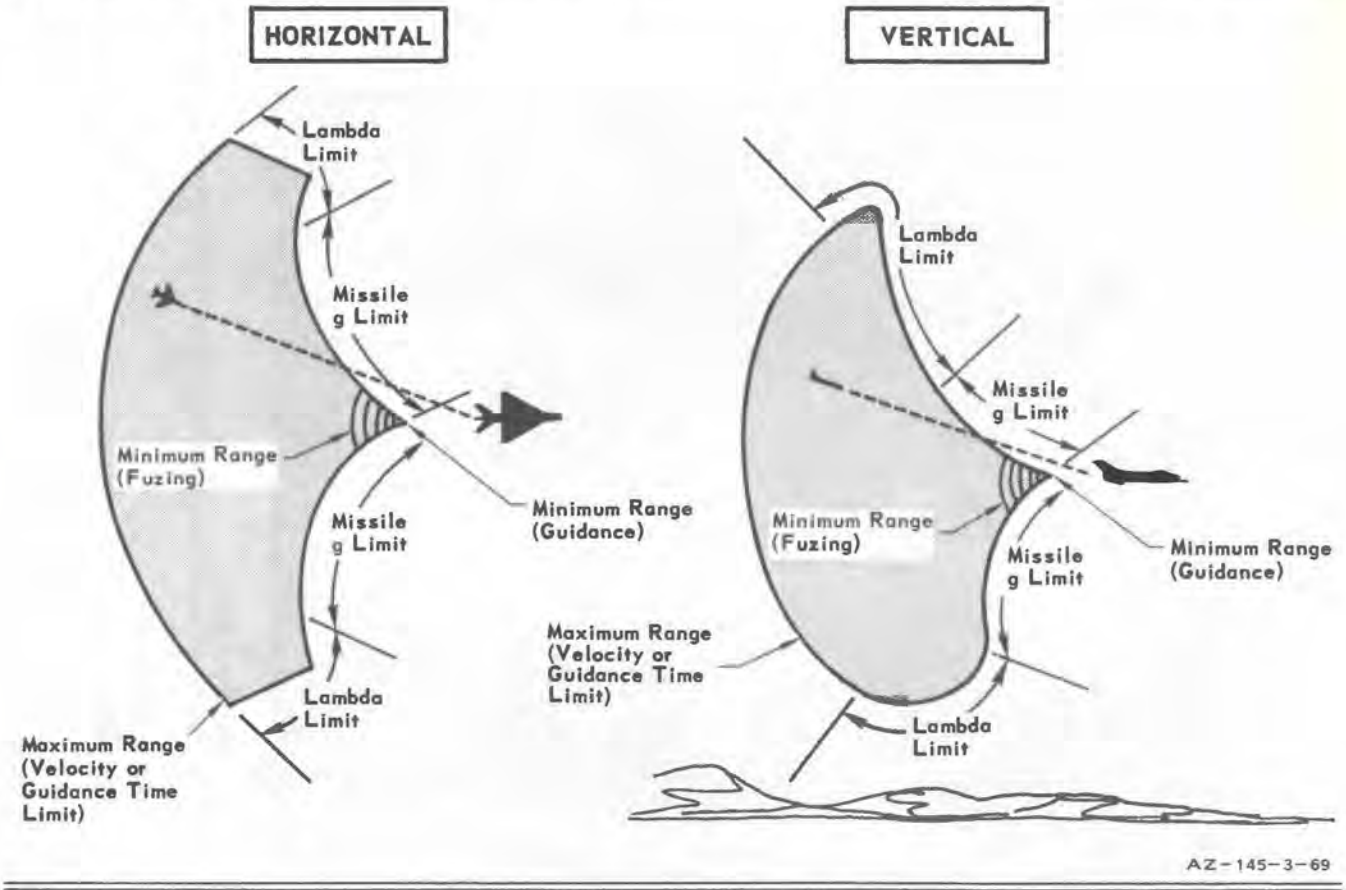


Figure 1–74

AIM-9C OPERATIONAL APPLICATIONS

AIM-9C non-maneuvering envelopes are presented in figure 1–76. When using AIM-9C, it is mandatory to realize that many times the electronic envelope (the range that sufficient radar return is available for proper guidance) is less than aerodynamic range limits in a forward hemisphere attack. The aircraft missile release computer displays aerodynamic maximum range and the occurrence of steady aural tones denote entry into the electronic range limit. Electronic guidance tones are affected by radar transmitter power and the ability of the AIM-9C receiver to distinguish the target return from background noise. As a general rule, steady AIM-9C tones can be expected at a ¼ to ⅓ the radar detection range of the target.

ALTITUDE LINE LIMITATIONS

The AIM-9C cannot be launched at targets 5,000 feet outside to 1,000 feet inside the altitude line due to the possibility of the missile shifting lock-on to the altitude line.

HOJ LIMITATION

The AIM-9C can home on a spot noise jamming source that occurs prior to launch or during time of flight provided that the source is continuous throughout time of flight. If the noise jammer is secured, the AIM-9C will go ballistic.

MANUAL TARGET ILLUMINATION

Successful launch of AIM-9C by boresighting the target in any of the acquisition modes is not possible.

FRONT QUARTER TECHNIQUES

AIM-9C missiles must be preselected for front quarter launching from aircraft without the deviated pursuit computer. The high closure rates associated with front quarter intercepts require rapid judgement as to the satisfaction of the aerodynamic, electronic, and altitude line limitations prior to launch. Generally, if the radar is weak, the occurrence of tones, proximity to the altitude line and minimum range virtually

AIM-9B Maximum Launch Range

CO-SPEED, CO-ALTITUDE, TAIL-ON ATTACK

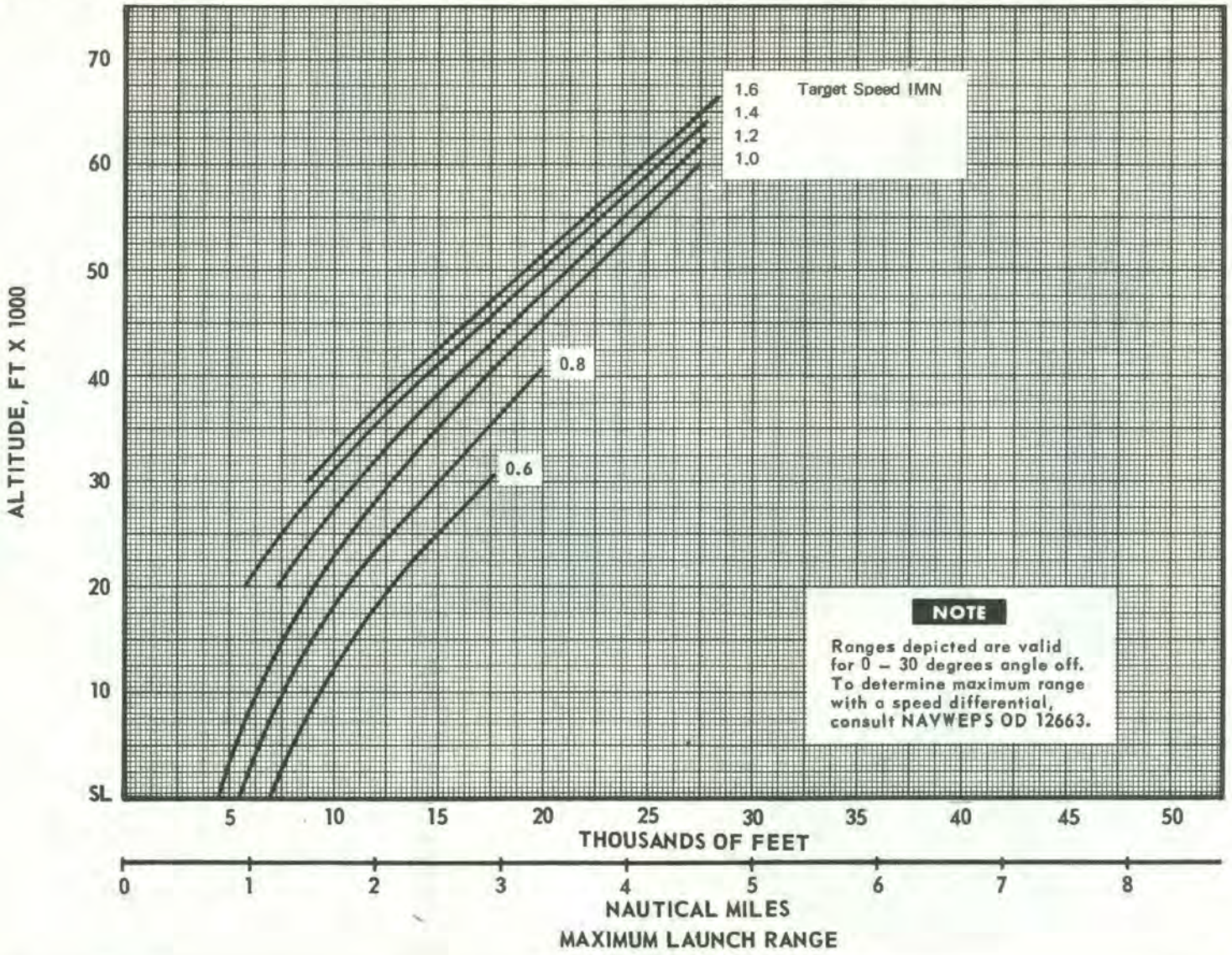
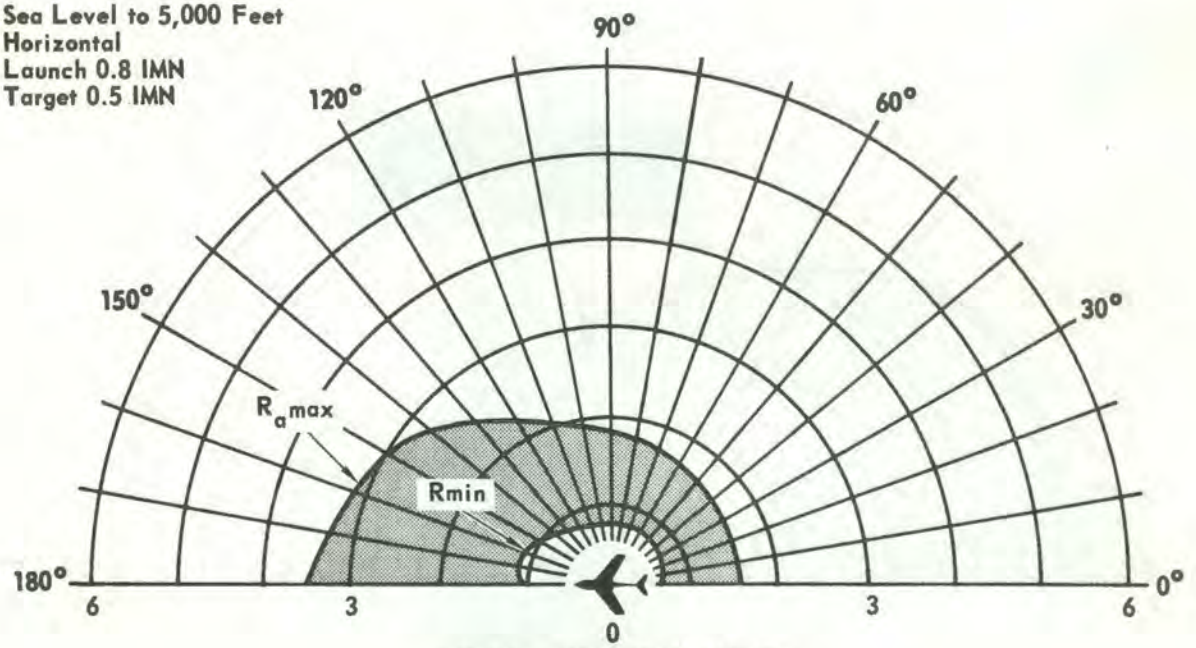


Figure 1–75

AIM-9C Launch Envelopes (Lead Launch)

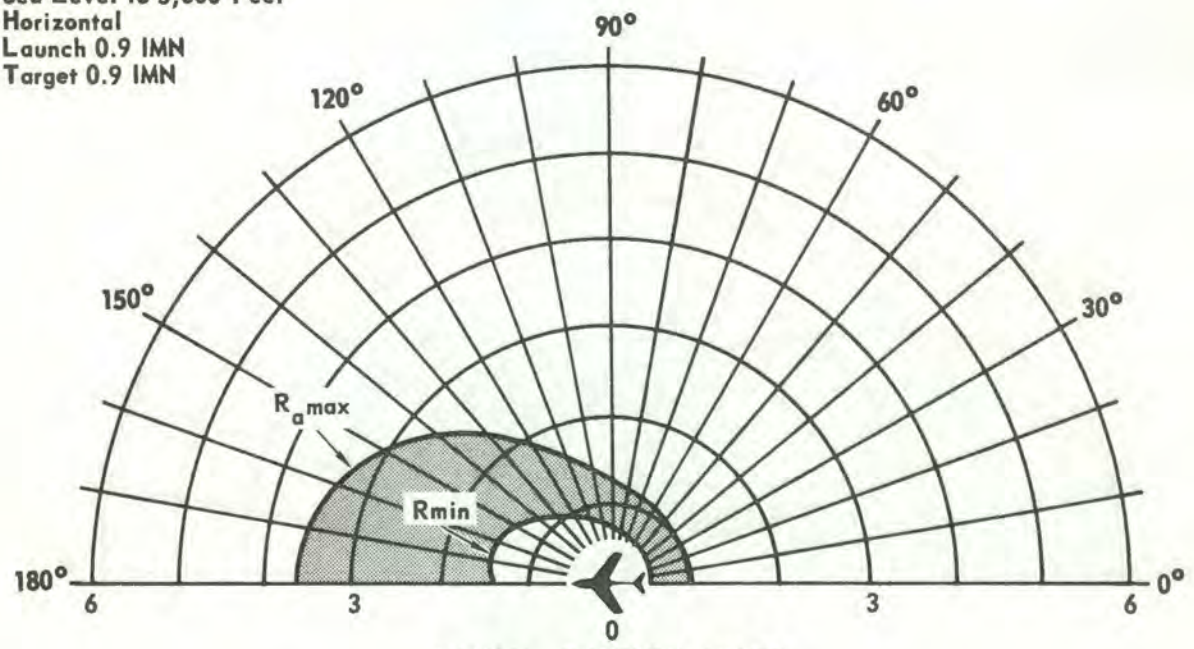
NON-MANEUVERING TARGET

Sea Level to 5,000 Feet
Horizontal
Launch 0.8 IMN
Target 0.5 IMN



RANGE – NAUTICAL MILES

Sea Level to 5,000 Feet
Horizontal
Launch 0.9 IMN
Target 0.9 IMN



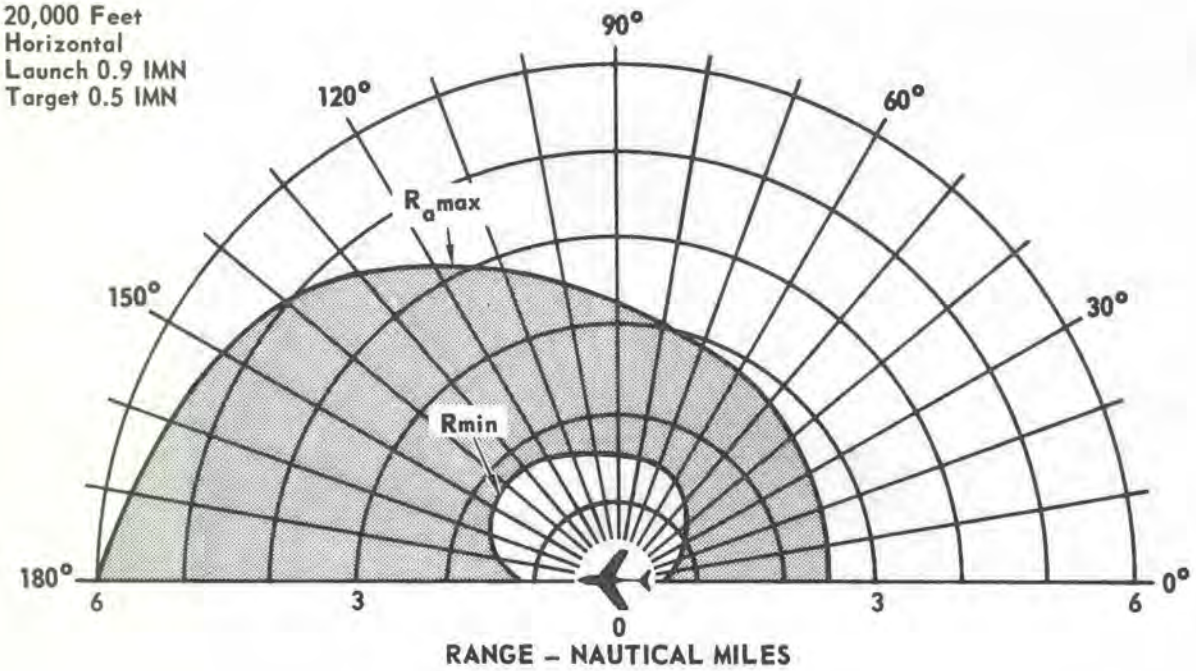
RANGE – NAUTICAL MILES

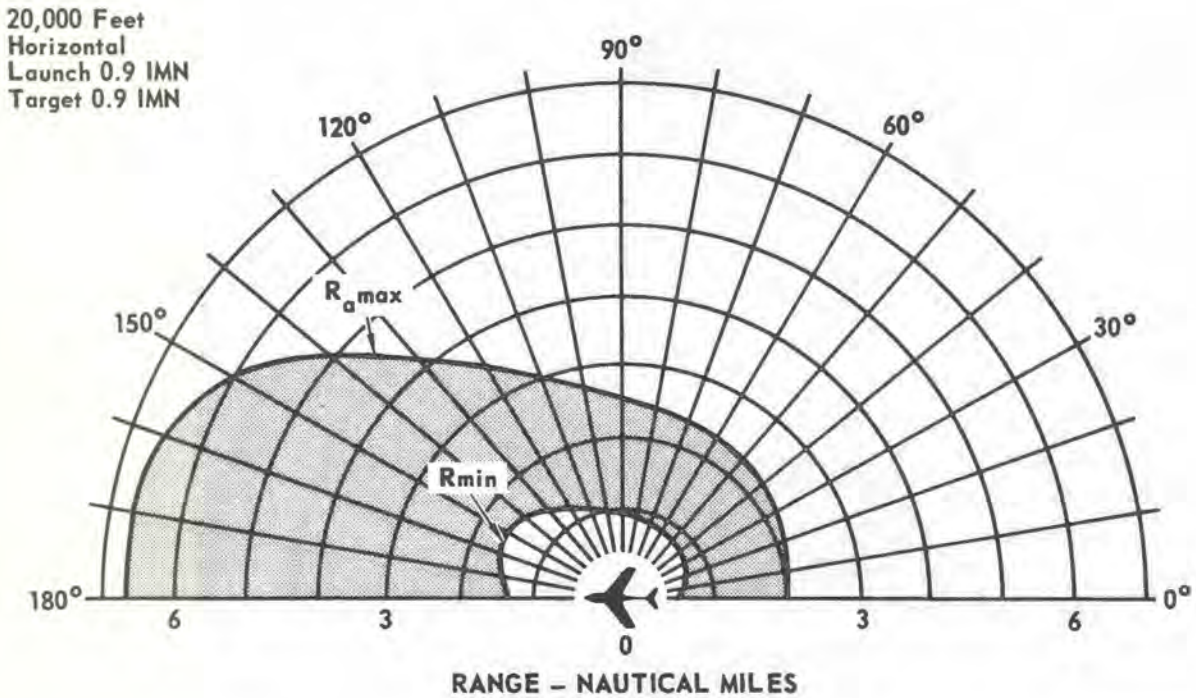
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Figure 1–76 (Sheet 1)

AIM-9C Launch Envelopes (Lead Launch)

NON-MANEUVERING TARGET



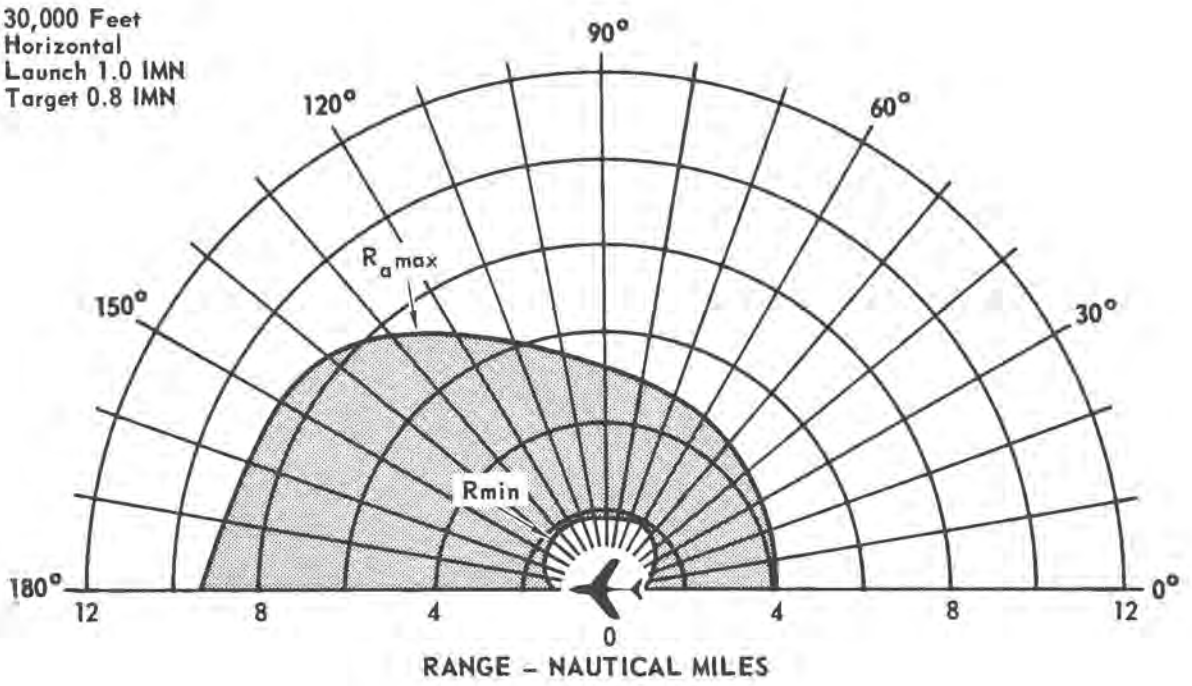


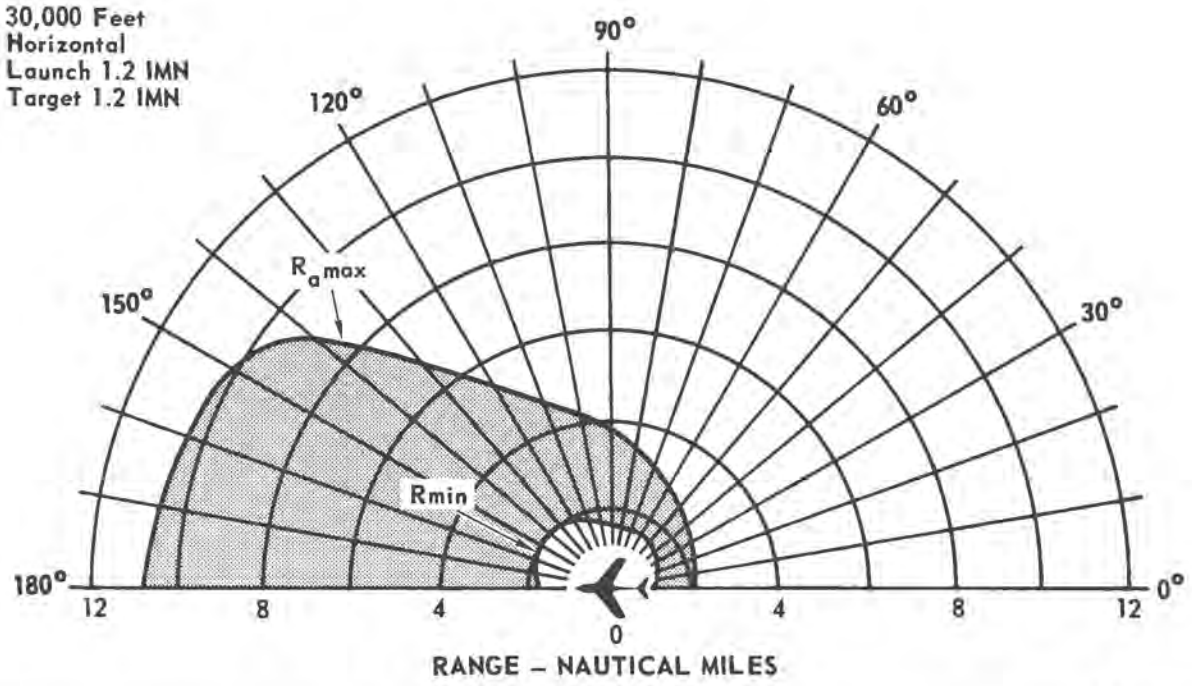
AZ-120(2)-11-66

Figure 1–76 (Sheet 2)

AIM-9C Launch Envelopes (Lead Launch)

NON-MANEUVERING TARGET





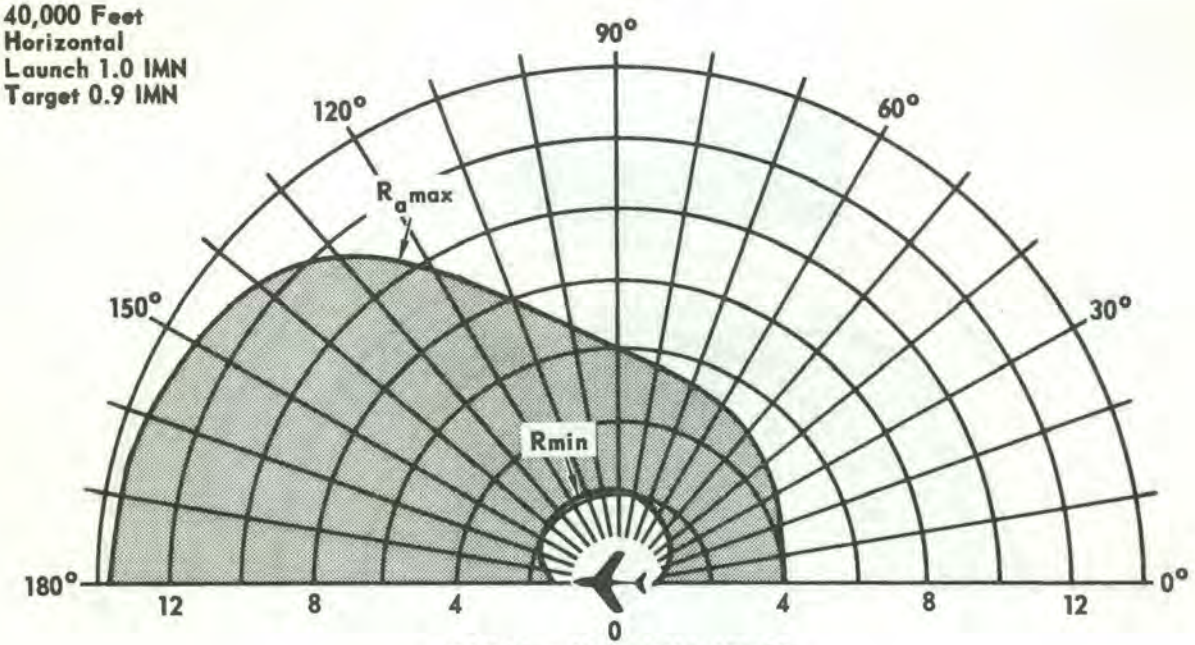
AZ-120(3)-11-66

Figure 1–76 (Sheet 3)

AIM-9C Launch Envelopes (Lead Launch)

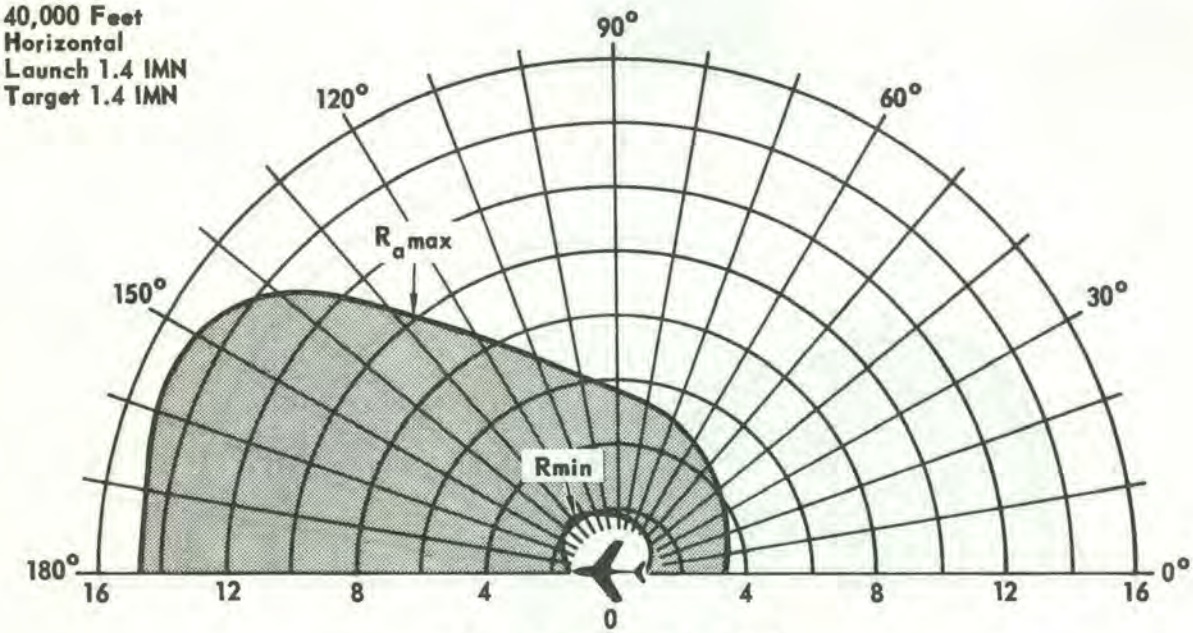
NON-MANEUVERING TARGET

40,000 Feet
Horizontal
Launch 1.0 IMN
Target 0.9 IMN



RANGE – NAUTICAL MILES

40,000 Feet
Horizontal
Launch 1.4 IMN
Target 1.4 IMN



RANGE – NAUTICAL MILES

AZ-120(4)-11-66

Figure 1–76 (Sheet 4)

eliminate the possibility of launch. Even with an excellent radar, multi-AIM-9C launch is rarely possible or recommended on a single attack.

IN-TRAIL TECHNIQUES

The tactical situation may allow simultaneous use of more than one fighter against a raid. The use of in-trail techniques permits a single controller to coordinate the attacks of more than one fighter. In-trail tactics will also permit both fighters of a section to employ the AIM-9C against a raid. Spacing between fighters will depend on the type of intercept being performed. For forward hemisphere attacks using AIM-9C missiles, six to seven miles between fighters should be used. Sufficient distance must be maintained to allow the first fighter to launch his missile and clear the area before the second fighter reaches firing range. The in-trail position should be flown in the search mode. This enables the trailing pilot to maintain surveillance of the overall tactical situation.

AIM-9C MANEUVERING TARGET CAPABILITY

AIM-9C has not been evaluated against maneuvering targets. Radar lock-on is a prerequisite for missile launching and, unless the F-8 is BAT-equipped, this is rarely possible during air combat maneuvering. The low altitude maneuvering target is generally always within altitude line firing restrictions. The high background noise level associated with low altitude flight also degrades AIM-9C performance.

AIM-9C GROUND CHECKS

Tuning the AIM-9C missile is generally accomplished while airborne; however, it is very important to make sure that the missile and oscillator color codes match during missile and cockpit preflight. When the aircraft has power applied, select the AIM-9C station with the armament selector switch, and ensure that the radar lamp illuminates on the armament control panel. If the radar lamp will not illuminate, or the IR lamp illuminates instead, a malfunction exists.

AIM-9C AIRBORNE TUNING

Tune the AIM-9C missile above 10M or with an up antenna tilt setting if below 10M. The radar must be on and in the search mode and the AIM-9C selected with the armament selector switch. Hold the missile tuning switch to LO for 1 minute, then hold the switch to HI until the tuning needle starts to deflect clockwise, and then immediately release the switch. The meter should hold at the 11 to 12 o'clock position.

Note

If the meter needle deflects clockwise, drops, and then deflects and remains at the 11 to 12 o'clock position, retune the missile — it is tuned to the wrong null.

If the missile is properly tuned and the needle is resting at the 11 to 12 o'clock position, lock-on to an airborne target or the altitude line to test the missile firing tones. At this point the needle should jump to the 2 o'clock position.

CAUTION

When carrying a dummy missile, do not depress the firing pickle as most dummy AIM-9C missiles do not have a gas grain servo saver and damage to the missile will result.

The missile tones from an airborne target are a function of the energy the AIM-9C missile sees. The tones are not related to computation of the aerodynamic firing envelope as computed by the missile release computer. It is not uncommon to be within the aerodynamic firing envelope without firing tones. Lack of firing tones indicates a weak radar or AIM-9C receiver or both. Generally AIM-9C missile tones can be expected at one-fourth to one-third of the initial detection range of an airborne target.

Occasionally when tracking a target down to minimum range, the AIM-9C missile tones will remain after the radar has returned to the search mode. In this case the missile has shifted lock onto the noise around the nose of the aircraft (Main Bang). Shifting the radar mode to IR and back should eliminate this.

Whenever AIM-9C missiles are tuned while aircraft are in section, note the movement of the needle on the tuning meter when turning away. If it returns to 9 o'clock, retune — the missile was tuned to the radar energy of the other aircraft.

PART 7 — WEAPON FIRING EXERCISES

MISSILE FIRING EXERCISE

Although combat missile firing is the only complete test of system readiness, missile firing exercises under controlled conditions provide a means of keeping a pilot proficient in operation of the weapons system. Safety considerations, such as area clearance and tow airplane vulnerability, require that AIM-9 firing operations be conducted under stereotyped conditions. The following procedures are compatible with FXP-2 but contain more detailed instructions and information. These procedures are based on firings against towed targets.

AIM-9B PROCEDURES

The facilities and personnel required to conduct a safe and successful AIM-9B firing operation consists of firing aircraft and chase aircraft, two aircraft and associated towed target system, GCI/CCI radar control, area clearance facilities (radar or air/surface search), and an officer conducting the exercise (OCE). The firing area can be checked for surface ships by either airborne visual observation or by surface/airborne radar search. The AIM-9B impact area is a 20-degree sector of a radius equal to 8,000 yards plus 300 yards for each 1,000 feet of altitude. If the firing is made with an angle-off, expand the sector by 10 degrees on the side of the target course away from the attack. These areas must be clear of all surface and airborne traffic from the surface to the firing altitude. The following procedures are applicable for AIM-9B firing operations against towed targets:

a. The exercise will be conducted according to the parameters prescribed by the OCE or FXP-2.

b. When possible, firings should occur in the center of the envelope to optimize missile performance and crew training. The safety arcs, within which missiles may not be launched, can be computed for co-altitude firings at the towed target. The missile launch may occur any time the firing aircraft is outside this safety arc, provided other envelope parameters of angle-off, tracking rates, and maximum and minimum range are satisfied. AIM-9B performance is optimized when the missile is fired at reduced angles-off and at ranges which do not approach extreme envelope limits. For missile firings below 20,000 feet, the angle-off should be within 20 degrees of the target's tail. Above 20,000 feet, limit firing angle-off to 40 degrees. Under certain firing conditions with higher angles-off, maximum range increases with angle-off; therefore, safety arcs would have to be increased.

c. Safety arcs are computed by adding 30 percent of R_{max} to R_{max}.

d. Figure 1–59 illustrates a typical firing exercise example which is based on the following factors:

Altitude	30,000 feet
Target Mach	1.0 Mach
Launch Mach	1.0 Mach
From figure 1–55, R_{max}	12,800 feet
Safety Arc	16,500 feet (12,800 × 0.3 plus 12,800)

With a cable scope of 10,000 feet, minimum firing range is 6,500 feet (16,500–10,000) dead astern or a safety arc of 16,500 feet on the tow aircraft (figure 1–77, Example 1). Maximum firing range is 12,800 feet from the towed target. If the tow system allows placing the target outside of the safety arc, as in Example 2, minimum range applies and launch may occur from any point in the envelope.

e. The airborne OCE is responsible for the following:

1. Confirming RENO
2. Confirming HOTSHOT by visually ascertaining if the ignition has occurred
3. Confirming IN-ENVELOPE
4. Giving CLEAR TO FIRE
5. Acting as a safety observer for area clearance, missile malfunction, or HUNG MISSILE, and confirming target tracking and not tow aircraft tracking.

f. All participants should exercise strict radio discipline as a safety precaution and for exercise efficiency.

g. FXP-2 clearly states the parameters for the firing exercise. However, the firing aircraft must be positioned to preclude violation of the safety arc at the time of firing.

h. "CLEAR TO FIRE" may be given by the OCE only if the following criteria have been met:

1. There are no surface or air targets within the splash pattern.
2. The OCE has contact with the tow aircraft, target, and firing aircraft either on the radar scope or visually.
3. The pilot has transmitted RENO and JUDY.

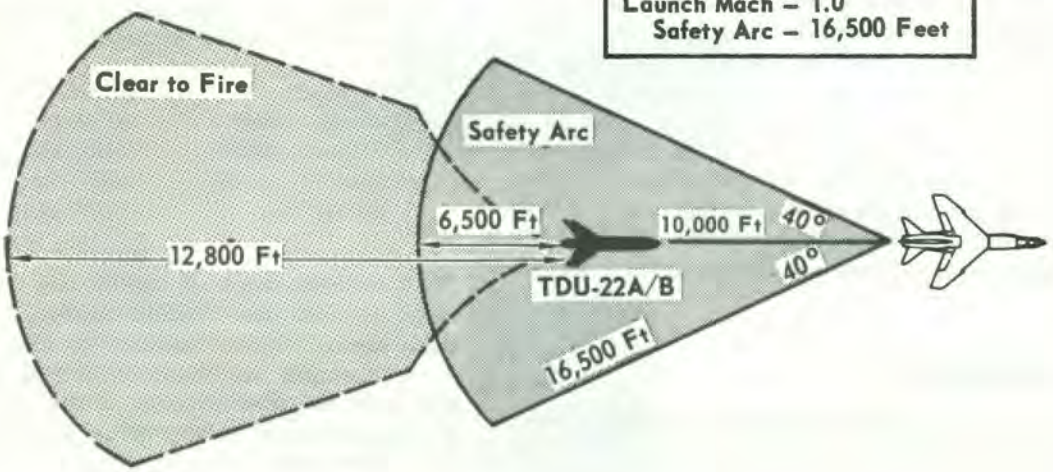
i. "BREAK IT OFF" shall be transmitted:

1. By the OCE when the firing airplane is at a minimum range to the target or approaching the tow aircraft safety arc.

AIM-9B Firing Exercise Examples

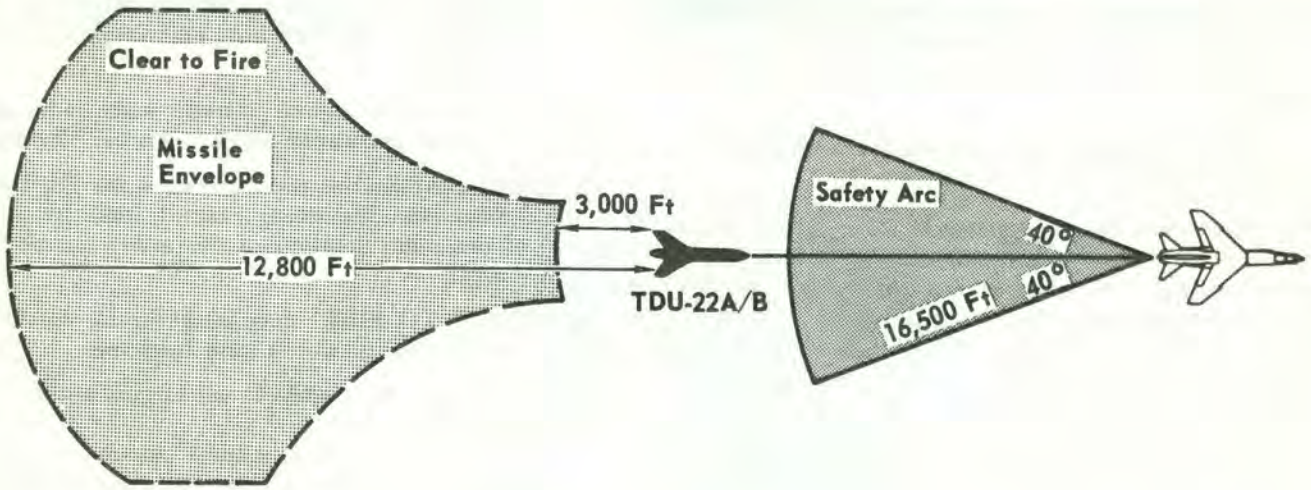
TOW TARGET INSIDE SAFETY ARC

EXAMPLE 1



TOW TARGET OUTSIDE SAFETY ARC

EXAMPLE 2



AZ-151-12-66

Figure 1–77

2. At any time, by anyone, if safety considerations warrant.
3. By the OCE if he has visual contact of the target and cannot confirm "HOTSHOT."
4. If the firing pilot elects to abort the run for any reason, the pilot will transmit "SKIP IT."

j. If the missile fails to fire, the firing pilot will transmit "HUNG MISSILE." The OCE will remind the pilot to "DE-ARM." Local ordnance safety procedures should then be observed.

AIM-9C PROCEDURES

Launch and safety parameters for the AIM-9C will be provided when available.

AIM-9D PROCEDURES

Launch and safety parameters for the AIM-9D will be provided when available.

AIR-TO-AIR MISSILE TARGETS

The targets which are normally used for firing exercises will be either powered or towed targets. The type targets and their descriptions are shown in figures 1–78, 1–79 and 1–80.

TRAINING INTERCEPTS

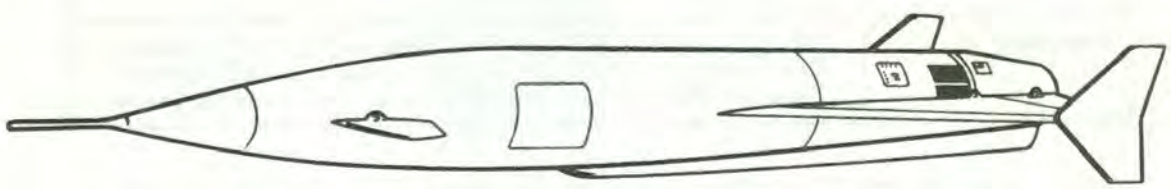
Fleet intercept training must be directed toward achieving the maximum degree of combat readiness. Therefore, intercept training should include high and low altitude and ECM environment training. The techniques and tactics used during these training intercepts should be the same as those used for actual intercepts which are described in Part 4 of this section.

AIR-TO-AIR GUNNERY

F-8 BANNER TOW PROCEDURES

The following procedures are recommended, weather and local flight regulations permitting. An MRT or CRT takeoff is made following banner hook-up. Climb at 160 KIAS, CRT, with the wing up and gear up to 10,000 feet; then 180 KIAS maximum to approximately 1,000 feet above tow altitude. The afterburner is secured, the wing lowered, and tow speed attained while descending to tow altitude. A 30,000-foot tow altitude may require lowering the wing passing 20,000 feet

AQM-37A Missile Target

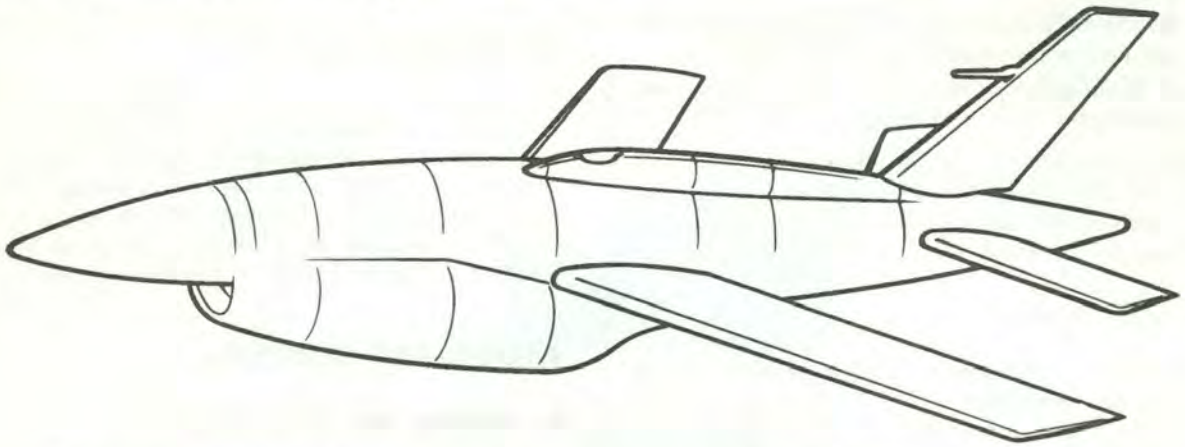


Dimensions	Length.....13 Ft, 6 In. Wingspan.....3 Ft, 4 In. Diameter.....1 Ft, 1 In.
Altitude	Minimum.....1,000 Ft Maximum.....70,000 Ft
Speed	0.9 to 2.0 Mach
Augmentation	Control and stabilization system, C and X band TWT, infrared flares, and aerodynamic destruct system

AZ-152-12-66

Figure 1–78

BQM-34A Missile Target



Dimensions	Length.....23 Ft Wingspan.....12 Ft, 11 In. Height.....6 Ft, 8 In.
Radar Reflectivity Unaugmented	Head-on..... One Square Meter Beam..... Four Square Meters
Altitude	Minimum..... 200 Ft Maximum.....50,000 Ft
Speed	10,000 Ft.....600 Knots 50,000 Ft.....550 Knots
Time on Station	50,000 Ft, 500 Knots .....86 Minutes
Augmentation	S-Band beacon, telemetry transmitting set standard equipment. Can be augmented with L, C, X band beacons, TWT, infrared flares, smoke, cameras, scoring devices, and countermeasures.

AZ-153-12-66

Figure 1–79

TDU-22A/B Towed Target

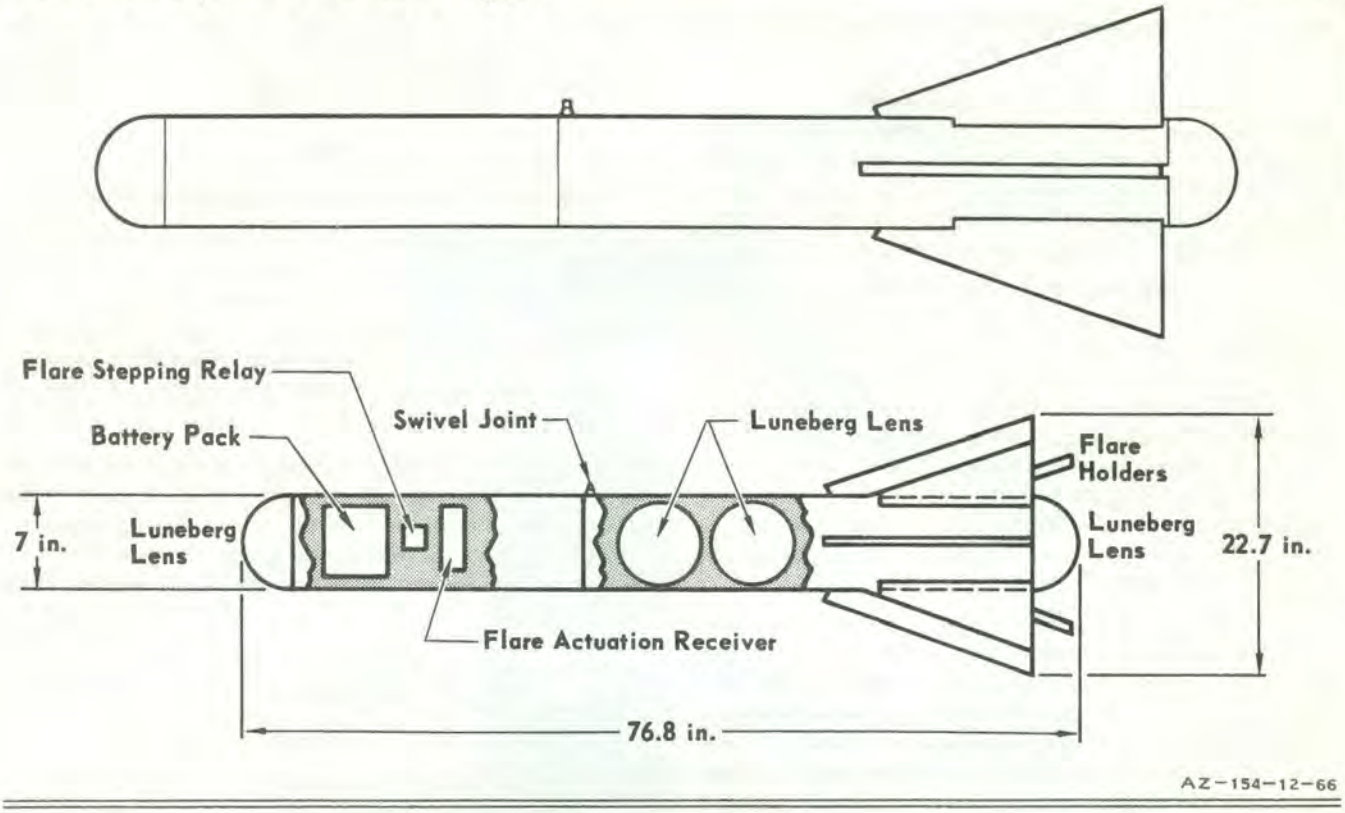


Figure 1–80

with a clean CRT climb to level off. Recommended tow speed is 220 KIAS at 20,000 and 30,000 feet.

Note

Consult NATOPS if changes in airspeed or altitude are desired because of cooling problems.

Abrupt control movements and excessive afterburner selection should be avoided to prevent unnecessary strain on the tow cable. During descent (wing up or down) maximum speed should be 180 KIAS when above 10,000 feet. Tow drop configuration should be wing up, 150 to 160 KIAS, at the altitude prescribed by drop area course rules, but not below 500 feet AGL.

IN-FLIGHT SIGHT CHECKS

If time permits, individual sight checks should be conducted prior to commencing the gunnery pattern. If sight checks are not performed prior to entering the gunnery pattern, or a member of the flight suspects that his fire control system is in error, he should inform the flight leader of this fact and allow enough fuel upon completion of the gunnery pattern to conduct a sight check before returning to base.

The sight check is performed at 350 (±10) KIAS, 20,000 (±500) feet with the gyro pipper uncaged, fixed range dial set at 1,500 feet, and the radar-fixed switch in the fixed position. A turn is commenced and g applied to displace the gyro pipper exactly 50 mils. Once the turn is steady, pick a point on the horizon and time the turn for any multiple of 360 degrees. The sight check should be performed in both directions. A time of 60.8 (±2) seconds F-8C/K 58.0 (±2) seconds F-8H/J is ideal for 360 degrees.

A quick check can be performed if time does not permit a normal check. The initial set-up is identical, but the turn is commenced and g applied to exactly 2.6 g's. The gyro pipper will be positioned on the 50-mil range if it is within the limits stated above. A pipper positioned at less than 50 mils indicates a tight sight and one positioned at more than 50 mils indicates a loose sight. The pilot can then adjust the range dial for proper sight solution if firing fixed, or note the mil discrepancy and apply correction while tracking in radar ranging gunnery. The quick check can be performed in 180 degrees of turn.

The radar system should be checked during this time interval with emphasis on GARO/BAT mode and all switches set for entry into the gun pattern.

MEDIUM ALTITUDE (20,000 FEET) GUNNERY PATTERN

The low altitude gunnery pattern should be conducted as follows:

a. The tow aircraft and escort establish an orbit at the rendezvous point. When the flight leader has the tow aircraft in sight, the escort can detach and join the firing group in trail position. The leader should maneuver the flight to the outside of the tow aircraft's turn, allowing the escort time to accelerate and join.

b. As the tow aircraft approaches 90 degrees and 45 degrees of turn to go, he should transmit same. The flight leader calls in on a spacer pass announcing "fly by side" and "perch side" with respect to the tow and "armament master on." Each succeeding aircraft calls in repeating spacing and perching instructions and confirming the armament master switch is on. Each flight member must adjust power and flight path as necessary to attain approximately one mile separation and twice the tow airspeed. Trim should be adjusted to "hands off flight" at firing speed.

c. Fly by the tow at his altitude, wings level, close aboard (100 to 300 feet). Abeam the tow, transmit "— — — — OFF." Add power to MRT, PULL UP WINGS LEVEL, (approximately 3g) to a 30-degree nose high attitude. After gaining approximately 3,000 feet, roll to at least 90 degrees of bank and fly above and across the flight path of the tow aircraft, keeping him in sight and continuing the climb.

d. After 70 degrees to 90 degrees of turn, and approaching the tow's abeam position (high reversal), smoothly reverse the turn and pick up the tow aircraft on the other side. Adjust bank angle to move out to the proper perch position of 10,000 to 12,000 feet abeam, slightly aft of the tractor, with a 6,000- to 7,000-foot altitude advantage, parallel to the tow heading with approximately 300 KIAS (this is the perch). After the range has been confirmed "HOT" and the area ahead has been checked, arm the guns on the perch by turning the ready/safe switch to READY.

Note

Select guns on the armament selector or move guns select switches to ON depending on A/C switch configuration.

e. As soon as the plane ahead has left the perch and is at the low reversal, call "— — — — IN." (In four-aircraft pattern your opposite flight member should be calling OFF; i.e. "One off"–"three in," "two off"–four in.") With power at MRT, commence a slightly nose down turn toward the banner accelerating. The low reversal should be 5,000 to 7,000 feet abeam to slightly aft of the banner; 3,000 to 4,000 feet above, with a minimum of 375 KIAS and 90 (±10) degrees of turn remaining to parallel the tow heading. Adjust power as necessary. Check that the radar mode switch is in the GARO/BAT mode. Commence tracking the banner with 60–70 mils fixed lead. As the pursuit curve develops (gyro pipper moves aft toward the banner), position the pipper slightly ahead of and above the banner. Note radar lock-on by the illumination of the GARO or BAT lamp.

Note

Do not retrim aircraft in the gunnery pattern.

f. At approximately 4,000 feet of range, depress the trigger to the first detent to start the camera running and open the gun bay purge doors. The aircraft will pitch slightly as the purge doors open. Firing speed and a steady to slightly increasing g should be attained by this time. Smoothly allow the pipper to drift aft to center it on the banner.

g. Track the banner smoothly for at least two seconds prior to firing; do not use rudders to correct the aim point. Commence firing when the firing range tone comes on. A one-second burst is desired. Ensure a descending flight path when firing. 15 degrees angle off is the minimum for firing on a banner (the banner is square at 11 degrees). Identify pattern position errors during the early stages of the run and correct them as far out as possible.

Note

It is necessary to maintain a 2:1 speed advantage over the banner within the final pursuit tracking cone. If this ratio is not maintained, the point of maximum g will occur outside of firing range. The resulting g bleed-off will induce an improper lead solution (fixed or radar), and the pipper will run ahead of the banner.

h. Cease firing when: (1) breakaway tone comes on; (2) when reaching minimum angle off; (3) when banner is one banner width above the horizon; (4) when the distance, as measured by banner width and pipper relationship indicates 900 feet.

Note

The pilot must *look through* the pipper and *focus on* the banner.

After firing, keep the "g" applied and smartly roll wings level and pass above and behind the banner. Never go below the banner, as there is danger of collision if the banner is shot off.

Note

A proper breakaway will place the firing aircraft between the banner and the tow aircraft's jet wash.

After passing over the banner, turn to parallel the tow aircraft's course and pass by as on the initial spacer pass. When abeam, transmit"— — — — OFF," and commence pull-up in the same manner as in the spacer pass.

Note

The call off position abeam the tow is a fixed and constant position and should be the position from which all other pattern corrections are made.

The pattern continues until reaching the end of the range. If a pilot loses sight of the banner and/or the other planes in the flight, he should call immediately and break off the run staying above tow altitude.

i. At the turn around end of the range, the tow aircraft should notify the leader that the end of the range is approaching and to "make the next run your last." The leader then calls "— — — — IN," stating "This is the last run this heading." Passing abeam the tow aircraft, the leader calls, "— — — — OFF, HALF RIGHT (LEFT)," reduce power to approximately 80 to 85 percent and fly to a position 20–45 degrees ahead of the tow's abeam, 4,000 to 6,000 feet above with an airspeed of 250–300 KIAS. Each succeeding aircraft, after calling off, joins in a 2,000–3,000-foot trail on the aircraft ahead. At this time each pilot reports his fuel state.

WARNING

Care should be taken to not depress the trigger in trail.

When the last plane calls off, the leader instructs the tow aircraft to turn and proceed back down range. He should remain high and to the outside of the tow aircraft's turn. As the tow aircraft nears the new heading, he announces 90 degrees and 45 degrees to go. The leader calls "IN ON SPACER, SPACING LEFT (RIGHT), PERCHING RIGHT (LEFT)," and proceeds in the same manner as in the first spacer pass.

j. On a badly sucked run, call "BREAKING OFF — SUCKED" and remain high to allow aircraft behind to complete his run. Adjust flight path enroute to the perch as necessary to adjust interval.

k. The entire pattern should be flown droop extended.

l. Prior to leaving the range, safety the gun as follows:

Guns ready/safe switch	SAFE
Armament master switch	OFF
Guns select switches	OFF

The gyro pipper should be caged prior to landing.

m. The flight leader must ensure an aircraft is assigned to escort the tow prior to leaving the range or until another flight has rendezvoused with the tow.

LOW ALTITUDE (5,000 FEET) GUNNERY PATTERN

The 5,000-foot gunnery pattern employs all the procedures outlined in the 20,000-foot pattern with the following exceptions:

a. Tow speeds (using an F-8 tractor) can be either 180 KIAS or 240 KIAS. Optimum shooting speed remains double the target tow speed.

b. Pitch off the tow is not as steep (approximately 15 degrees) and begins abeam the tractor.

c. Perch altitude is 10,000 feet with 7,500 feet for the reversal.

d. Pattern orientation remains essentially the same as the 20,000-foot pattern for either tow speed. Tracking runs appear slightly more acute.

e. The 5,000-foot time circle check is identical to the 20,000-foot check except that the desired time is 68 (±2) seconds with about 2.1g at 50 mils.

COMMUNICATIONS

a. Two-way radio communications is mandatory for entry into the gunnery pattern. In the event of radio failure in the pattern, rock wings passing the tow aircraft on the next fly-by. The tow aircraft then notifies the rest of the flight. Normal pattern geometry should be flown, joining on the perch side of the tow aircraft on the next run. Remain joined on the tow until given the "by-by" signals, then detach and join a flight member for escort to base.

b. It is mandatory for each member of the flight to call "IN" and "OFF" on each run. In addition, if sight of the tow or aircraft ahead in the pattern is lost, immediately declare it, to enable other members of the flight to assist.

Note

Use of a survival mirror by the tow pilot will greatly assist the firing aircraft during poor visibility conditions.

EMERGENCIES

If any emergency is experienced at any time during the flight, advise the flight leader of the situation. If immediate return to base is necessary, a member of the flight should be detached as escort. With runaway guns or cycling generator, keep the aircraft pointed at the ground and turn the master armament switch "OFF," and guns ready/safe switch to "SAFE." Do not recharge guns after they have stopped.

HIGH ALTITUDE (30,000 FEET) GUNNERY PATTERN

The high altitude gunnery pattern employs all the procedures outlined in the low altitude pattern with the following exceptions/additions:

a. The afterburner must be used in the spacer pass to attain at least 1.15 IMN with the droops retracted.

b. The pitch-off abeam the tow is identical with the exception that the droop must be lowered prior to decelerating through 1.0 IMN and buffet onset caused by the applied g. If desired speed is attained on the fly-by, the afterburner may be de-selected as the roll across the top of the tow is commenced.

c. The turn toward the high reversal is continued for 90 to 100 degrees, placing the aircraft approximately 20 degrees aft of the tow's abeam position. This slightly sucked high reversal is required to allow time and distance to climb to the perch without becoming acute. The high reversal should be at 35,000 to 36,000 feet.

d. The perch is wider (2½ to 3 miles) and at least 8,000 feet above the tow. (10,000 feet is not uncommon.) The airspeed should be no less than 300 KIAS or 0.9 IMN. The perch should be slightly aft of the tow so that the turn off the perch will not place the shooter any farther forward than abeam the tow aircraft. Afterburner may be selected at any time to ensure a proper perch.

e. The turn off the perch must be a very smooth and coordinated maneuver with angle of bank applied as necessary to complete the turn approximately abeam the tow aircraft. Afterburner, if not already selected, must be selected commencing the turn off the perch. The droops are retracted passing 0.98 IMN, and left retracted for the remainder of the run.

f. The low reversal should be 7,000 to 9,000 feet abeam the banner, and 4,500 to 5,500 feet above. The airspeed out of the reversal should be a minimum of 400 KIAS (1.1 IMN).

Note

Positioning is much more critical and is difficult to achieve in the 30,000-foot pattern.

The extended use of the afterburner causes a considerably higher fuel consumption rate and the possibility of exceeding engine maximum temperature limitations.

DART GUNNERY

In the TDU-10A DART you will find a target which will sharpen your loose-deuce flying and one in which you can better judge your own abilities as a tactical gunfighter. The DART is a honeycombed cardboard, aluminum-covered towed target with the advantages that it can be maneuvered, towed at highspeed at low drag, and is less expensive than the Aero 35D banner.

You will probably find that the loose-deuce you have been fighting either keeps you at too great a range for an actual guns attack or that you have had inadequate tracking time. It will make you appreciate the extra effort involved in yo-yoing out of a guns firing position so that your wingman can fire. If you use the DART correctly, you should find that both your personal tactical gunnery improves and that you will be better able to coordinate a guns attack with your wingman.

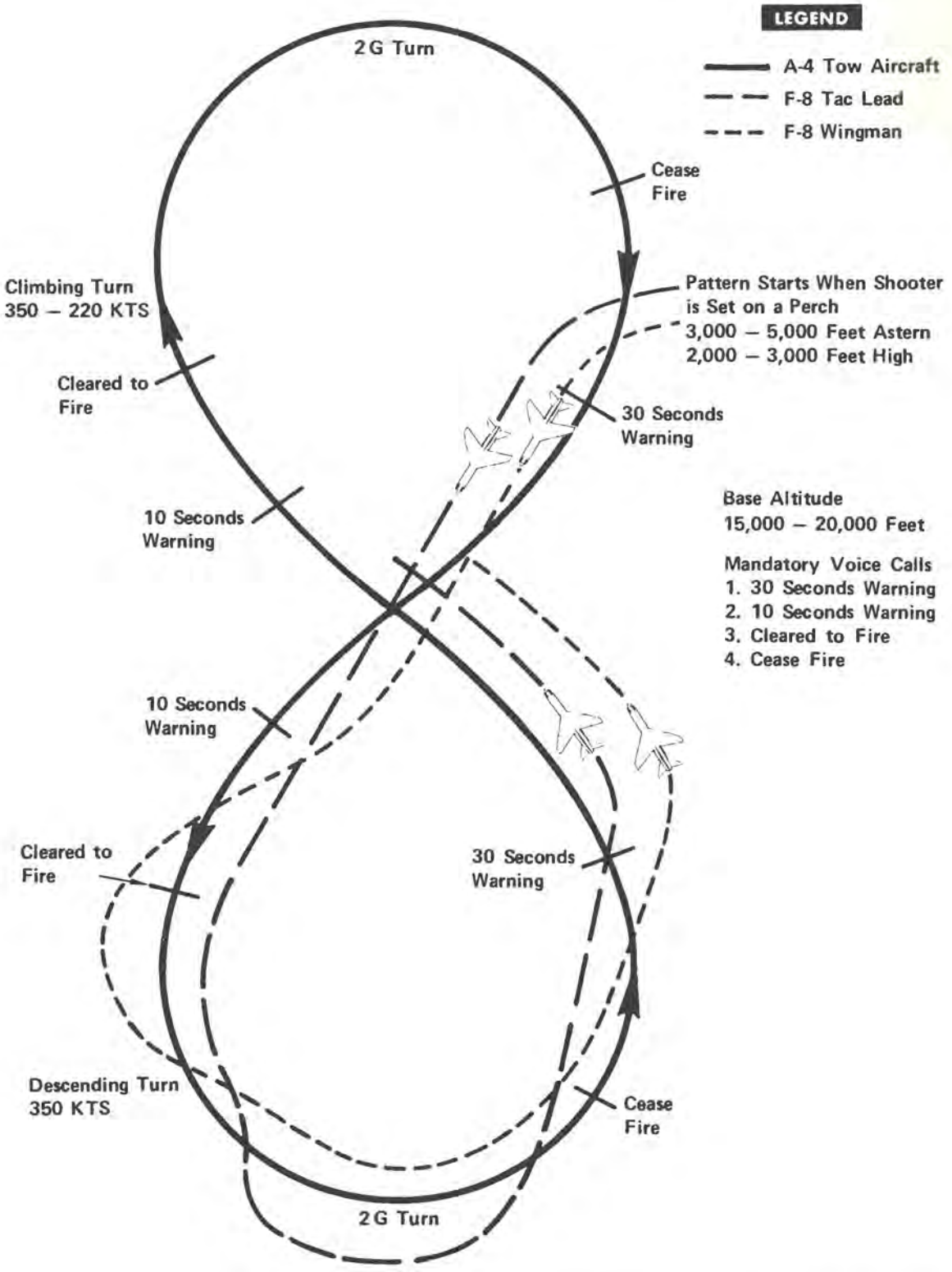
WARNING

Due to the aerodynamic shape of the target and the flying harness attached, DO NOT attempt to fly directly over the DART.

A four plane flight will break up into two sections. The second section will position themselves on a trailing perch from which they can roll in on the target should the firing section lose sight of it. The tow pilot will be established in his turn (figure 1–81) before calling CLEARED TO FIRE and conversely will not roll out of his turn before calling CEASE FIRE and receiving a ROGER, CEASE FIRE from the shooting section. The shooter should use his judgment when to start his run after the 30-second warning has been given, so as not to arrive within range before the CLEARED TO FIRE and, also, so as not to be involved in a long tail chase with the target. He should keep in mind that he must yo-yo off his run in time to allow his wingman to complete his attack before the tractor calls CEASE FIRE.

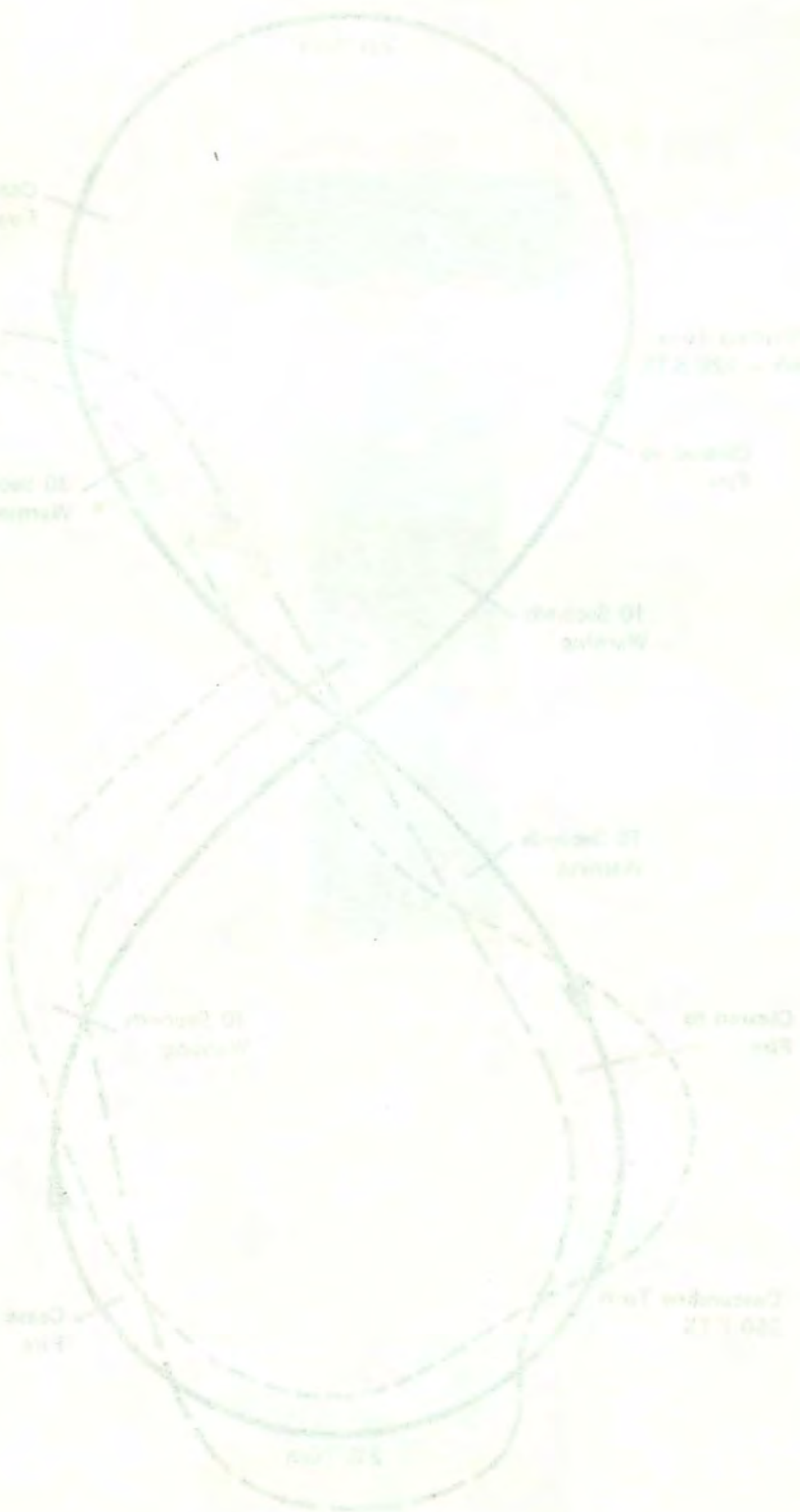
He should concentrate on a smooth tracking run, controlling his rate of closure to maintain not less than 50 knots above tow airspeed. The sight picture at firing range should be known to provide a backup for the radar.

Basic DART Pattern



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Figure 1–81



section II
conventional air-to-ground warfare

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PART 1—PLANNING

TARGET PLANNING FACTORS

ELEVATION

The elevation of the target, above mean sea level, should be known so that planned release conditions can be accurately met. The higher the target above sea level, the greater the altitude loss will be during pullout.

TERRAIN

The terrain of the target and its surrounding area play an important part in planning an attack mission. The terrain may restrict the attack to specific headings and/or maneuvers. It must be assumed that the enemy is aware of these restrictions and will defend the target area accordingly. When proceeding to and from the target, irregularities in terrain can be used to hide from the enemy radar and to remain outside the enemy SAM envelope.

SEA TARGETS

Generally, the most effective attack can be accomplished by employing several aircraft, each making a high-speed, low-level approach from different directions. A pop-up maneuver to various glide angles followed with a low turning recovery is recommended. Reattack, if required, should be made with an approach heading different from the initial attack. Coordination of attacking aircraft is mandatory and maximum use of the UHF is necessary.

WEATHER

When adverse weather exists, modification of tactics will be required. When maneuvering under an overcast, avoid flying close to the ceiling. The enemy will know the height of the overcast and set his defenses accordingly. Target entry and delivery tactics under an overcast may preclude the basic tactics described in Section II. The roll-ahead and the off-set entry maneuvers must be modified when operating below 5,000 feet. Abrupt pop-ups, rapid roll rates and minimum tracking time are associated with these modified entries; however, basic recovery criteria cannot be compromised.

DEFENSES

Refer to the F-8 Tactical Manual (SECRET) for information on enemy defense.

WEAPON SELECTION

Weapon selection is a function of many variables which include: aircraft operating limitations, aircraft configuration, launch and recovery limitations, aircraft carriage limitations, weapon and fuze availability, target characteristics, mission purpose, and range to target. For weapon employment and effectiveness data, refer to NWIP 20-1, Commander Seventh Fleet Air to Surface Weaponeering Handbook (COMSEVENTHFLT INST PO3310 series) or the Joint Munitions Effectiveness Manual.

EXTERNAL ARMAMENT LIMITATIONS

WARNING

Due to the complexity, construction and aerodynamic variation of the various stores, limitations for carriage and safe release have been determined and are included in this section. Only these stores may be carried or released to the limiting parameters shown. All releases were done with landing gear retracted and wing down. General lettered notes included must be applied to all releases, while specific notes are numbered and included under remarks.

CAUTION

In landing configuration, lateral control effectiveness is marginal in rolls away from a maximum asymmetrical load at normal approach speeds. As IAS is further decreased, lateral control deteriorates rapidly. It is recommended that all landing approach turns with asymmetrical loads be made banked away from the heavy side. If the aircraft should then be allowed to decelerate until loss of bank angle occurs, the aircraft will roll toward a wings level attitude. Both lateral and directional control are marginal when landing in a crosswind in excess of 10 knots from the direction opposite the asymmetrical load.

The external stores delivery system of the F-8 aircraft provides capability for delivery of a variety of bombs,

rockets, and missiles against air, sea, and surface targets. Figure 2–1 depicts the symbols for identifying the various carriage racks and station locations in determining stores limitations from figure 2–2.

The armament system consists of cockpit controls, 2 to 4 fuselage stations and 2 wing pylons capable of carrying multiple racks with associated circuitry. The armament controls are electrical and permit the pilot to arm and release the various stores singly or in Salvo. The optical sight on top of the pilot's instrument panel combines fixed pipper and lead computing functions.

Note

Many bombs and rockets have higher airspeed limitations than the fuzes most commonly used with them. Therefore, particular care must be taken to ensure that planned carriage and release airspeed are within the limits of both the bomb and the fuze.

CARRIER OPERATING LIMITATIONS

Carrier operations are not permitted at gross weights in excess of 30,000 pounds with asymmetrical external wing stores loadings.

CAUTION

Nosewheel effectiveness is significantly reduced at gross weights in excess of 30,000 pounds, or with an asymmetrical wing stores loading imbalance to starboard. Nosewheel steering is totally ineffective to the left with a 2,000-pound asymmetrical load on the starboard wing.

Catapult launches with an asymmetrical external wing loading imbalance in excess of 2,000 pounds are not permitted.

Lateral stick force in addition to full lateral trim will be required for catapult launches and arrested landings with asymmetrical external wing stores loading approaching an imbalance of 2,000 pounds.

Asymmetrical external wing stores loading imbalance should be such that the greater weight is to port.

Arrested landings with external stores should be avoided wherever possible. However, if required, arrested landings with nonexpendable/nonjettisonable stores, or under emergency conditions, may be conducted within current gross weight limitations providing external wing stores loading per station and asymmetrical wing stores loading imbalance, if any, does not exceed 2,000 pounds.

Barricade engagements are permitted. Jettison external stores if possible. Stores will not interfere with barricade engagement but may tear loose and present a hazard to flight deck personnel. Refer to applicable Aircraft Recovery Bulletins for recommended engaging speeds.

TOW TARGET LIMITATIONS

For limitations and operating procedures refer to F-8 NATOPS Flight Manuals, Section VIII, Tow Target Systems.

AIRSPEED LIMITATIONS

The maximum permissible indicated airspeeds in smooth or moderately turbulent air are as follows:

With arresting hook, landing gear, speed brake, and wing leading edge droop retracted and wing down ..... As shown in figure 2–3

Carrying AIM-9B missile with Mk 8 Warhead .....Refer to figure 2–5

Note

Refer to NATOPS Flight Manual for additional limitations.

POWER CONTROL HYDRAULIC SYSTEM

With one power control hydraulic system inoperative, operation is restricted to the following limits:

Maximum acceleration — (PC 1 out) 4.0g
— (PC 2 out) same as "yaw stab inoperative" (figure 2–3)

Note

Refer to NATOPS Flight Manual for additional limitations.

TRIM AND STABILIZATION SYSTEM

In the clean condition, with only the roll stabilization system inoperative, restrictions are not changed from basic aircraft restrictions. With yaw stabilization and rudder-aileron interconnect systems inoperative, the following restriction applies:

Maximum permissible load factors — See figure 2–3.

Note

Refer to NATOPS Flight Manual for additional limitations.

MANEUVERS

The following maneuvers are not permitted:

Rolls:

Without wing stores — Rolls in excess of 360-degree bank angle change.

External Stores Limitations Symbols

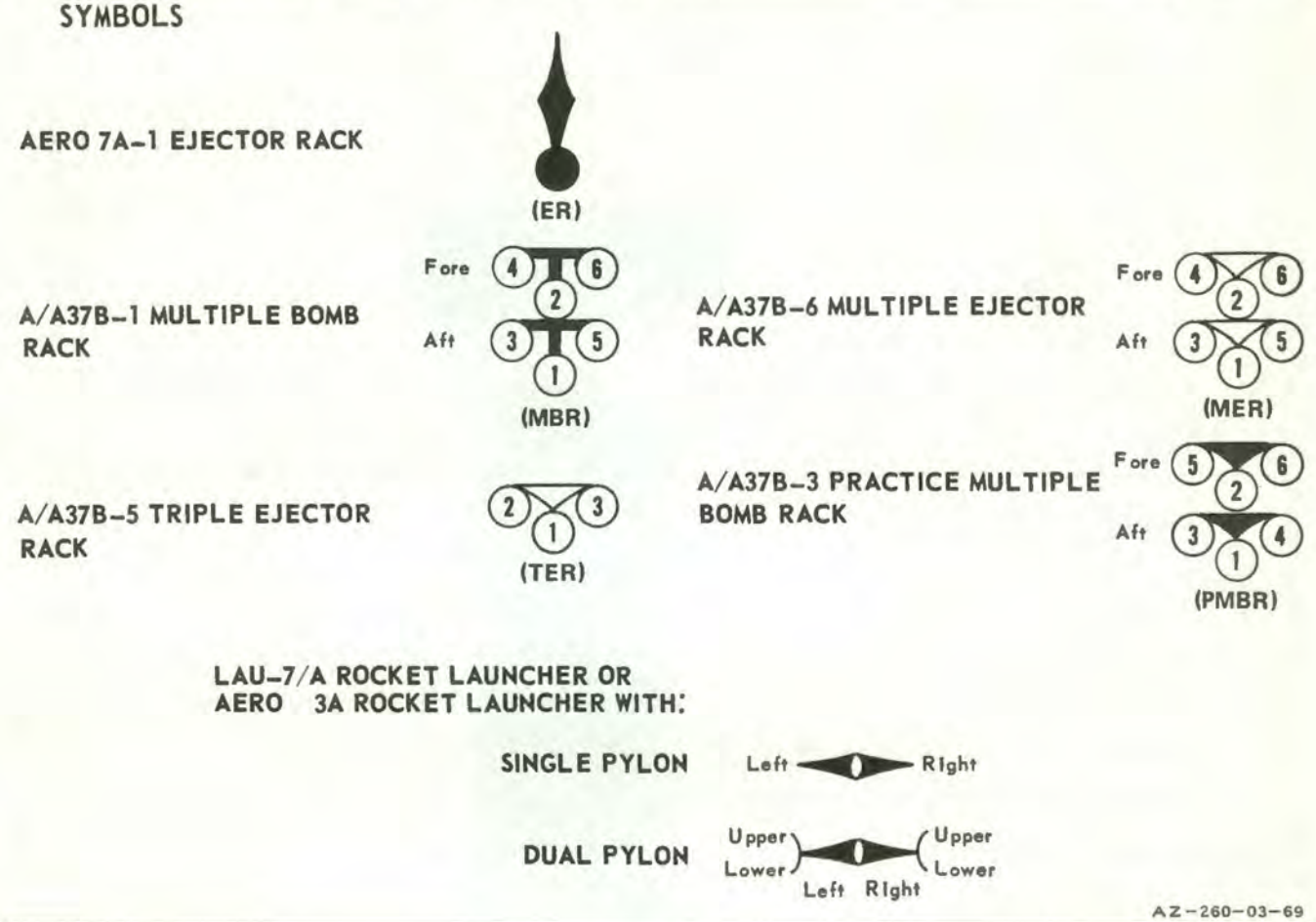


Figure 2-1

With wing stores — Full aileron rolls in excess of 180-degree bank angle change.

Clean condition stops aileron rolls in excess of 360-degree bank angle change.

Intentional Spins

ACCELERATION LIMITS

The maximum accelerations permitted for symmetrical and asymmetrical flight in smooth air or light turbulence are shown in figures 2-3 and 2-4. When flying in conditions of moderate turbulence, it is essential that accelerations from deliberate maneuvers be reduced 2.0g below that shown in figure 2-4. This is to minimize the possibility of overstressing the aircraft as a result of the combined effects of gust and maneuvering loads.

The maximum negative acceleration for symmetrical flight is -2.4g up to 725 KIAS and 0g for 725 KIAS for aircraft without wing stores. With wing stores the maximum negative acceleration for symmetrical flight is -2.0g.

PYLONS, RACKS AND WEAPONS COMPATIBILITY

Pylons, racks and weapons compatibility is illustrated in figure 2-6.

External Stores Limitations (F-8 Aircraft)

LINE NUMBER	STORE	STATION LOADING AND SUSPENSION L	LF	RF	R	MAXIMUM KIAS OR IMN WHICHEVER IS LESS CARRIAGE	LAUNCH	RELEASE	JETTISON	ACCELERATION "g" CARRIAGE	LAUNCH	RELEASE	JETTISON	MAX. DIVE FOR DEL	REMARKS/LIMITATIONS
1	MK 81 Conical Fin					620/ 1.5		550/ 0.95	550/ 0.95	LBA		+0.5 To +4.5	+0.5 To +4.5	70°	For release from MBR – see note 4. TER – see note 2.
2						550/ 1.5		550/ 0.95	Note 5	LBA		+1.0 To +4.5	+1.0 Note 5	40°	
3						550/ 1.5		550/ 0.95	Note 5	LBA		+0.5 To +4.5	+1.0 Note 5	70°	
4						530/ 1.5		550/ 0.95	Note 5	LBA		+0.7 To +4.5	+1.0 Note 5	45°	
5						550/ 1.5		550/ 0.95	Note 5	LBA		+0.5 To +4.5	+1.0 Note 5	70°	
6															
7	MK 81 Conical or Snakeye Fin with M-1 Bomb Fuze Extension					475/ 0.95		475/ 0.85	475/ 0.85	0.0 To +4.5		+0.5 To +4.5	+0.5 To +4.5	Unret. 70° Ret. 40°	See notes 1 and 3. For release from MBR – see note 4. MBR must be configured for 500-pound bomb (95-inch suspension). MK 14 Mod 1 fin restricted to 350 KIAS for retarded release. Single release only in retarded mode. See note 7 for Snakeye fin.
8						475/ 0.95		475/ 0.85	Note 5	0.0 To +4.5		+1.0 To +4.5	+1.0 Note 5	40°	
9						475/ 0.95		475/ 0.85	Note 5	0.0 To +4.5		+1.0 To +4.5	+1.0 Note 5	Unret. 70° Ret. 40°	
10						475/ 0.95		475/ 0.85	Note 5	0.0 To +4.5		+1.0 To +4.5	+1.0 Note 5	Unret. 70° Ret. 40°	
11															
12															

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Figure 2–2 (Sheet 1)

External Stores Limitations (F-8 Aircraft)



LINE NUMBER	STORE	STATION LOADING AND SUSPENSION L	LF	RF	R	MAXIMUM KIAS OR IMN WHICHEVER IS LESS CARRIAGE	LAUNCH	RELEASE	JETTISON	ACCELERATION "g" CARRIAGE	LAUNCH	RELEASE	JETTISON	MAX. DIVE FOR DEL	REMARKS LIMITATIONS
1	MK 81 Snakeye Fin					620/ 1.5		550/ 0.95	500/ 0.95	LBA		+0.5 To +4.5	+0.5 To +4.5	70°	For release from MBR – see note 4.
2						550/ 1.5		Unret. 550/0.95 Ret. 500/0.95	Note 5	LBA		+0.5 To +4.5	+1.0 Note 5	Unret. 70° Ret. 40°	Single release only in retarded mode. MK 14 Mod 1 fin restricted to 350 KIAS for retarded release. See note 7 for Snakeye fin.
3															
4						550/ 1.5		Unret. 500/0.95 Ret. 500/0.95	Note 5	LBA		+1.0 To +4.5	+1.0 Note 5	40°	
5						550/ 1.5		Unret. 550/0.95 Ret. 500/0.95	Note 5	LBA		+0.5 To +4.5	+1.0 Note 5	Unret. 70° Ret. 40°	
6															
7	MK 82 Conical Fin + MK 36 DESTRUCTOR CON - FIN					LBA		550/ 0.95	550/ 0.95	LBA		+0.5 To +4.5	+0.5 To +4.5	70°	For release from MBR – see note 4. TER – see note 2. SEE NOTE 11
8						LBA		550/ 0.95	Note 5	LBA		+0.5 To +4.5	+1.0 Note 5	70°	
9						LBA		550/ 0.95	Note 5	LBA		+0.7 To +4.5	+1.0 Note 5	45°	
10						550/ 1.5		550 0.95	Note 5	LBA		+1.0 To +4.5	+1.0 Note 5	40°	
11						550 1.5		550 0.95	Note 5	LBA		+0.5 To +4.5	+1.0 Note 5	70°	
12															

Figure 2–2 (Sheet 2)

External Stores Limitations (F-8 Aircraft)



LINE NUMBER	STORE	STATION LOADING AND SUSPENSION L	LF	RF	R	MAXIMUM KIAS OR IMN WHICHEVER IS LESS CARRIAGE	LAUNCH	RELEASE	JETTISON	ACCELERATION "g" CARRIAGE	LAUNCH	RELEASE	JETTISON	MAX. DIVE FOR DEL	REMARKS/LIMITATIONS
1	MK 82 Conical or Snakeye Fin with M-1 Bomb Fuze Extension Destructor MK 36					475/ 0.95		475/ 0.85	475/ 0.85	0.0 To +4.5		+0.5 To +4.5	+0.5 To +4.5	Unret. 70° Ret. 40°	See note 3. MBR must be configured for 500-pound bombs (95-inch suspension). For release from MBR – see note 4. Single release only in retarded mode. See note 7 for Snakeye Fin. SEE NOTE 11 **CAUTION** When utilizing retarded MK 82 Snakeye bombs, use the minimum release altitudes specified for unretarded MK 82 Snakeyes. This will ensure safe escape in the event of Snakeye fin failure. Not applicable to the improved retarded fin, MK 15 Mod 3.
2						475/ 0.95		475/ 0.85	Note 5	0.0 To +4.5		+0.5 To +4.5	+1.0 Note 5	Unret. 70° Ret. 40°	
3						475/ 0.95		475/ 0.85.	Note 5	0.0 To +4.5		+1.0 To +4.5	Note 5	40°	
4						475/ 0.95		475/ 0.85	Note 5	0.0 To +4.5		+0.5 To +4.5	+1.0 Note 5	Unret. 70° Ret. 40°	
5															
6	MK 82 MK 124 Snakeye Fin Destructor MK 36					620/ 1.5		Unret. 550/0.95 Ret. 500/0.95	500/ 0.95	LBA		+0.5 To +4.5	+0.5 To +4.5	Unret. 70° Ret. 40°	For release from MBR – see note 4. Single release only in retarded mode. See note 7 for Snakeye Fin. SEE NOTE 11 **CAUTION** When utilizing retarded MK 82 Snakeye bombs, use the minimum release altitudes specified for unretarded MK 82 Snakeyes. This will ensure safe escape in the event of Snakeye fin failure. Not applicable to the improved retarded fin, MK 15 Mod 3. This caution is not applicable to MK 36 Destructor. SEE NOTE 11
7						550/ 0.95		Unret. 550/0.95 Ret. 500/0.95	Note 5	LBA		+0.5 To +4.5	+1.0 Note 5	Unret. 70° Ret. 40°	
8															
9						500/ 0.95		500/ 0.95	Note 5	−1.0 To +5.0		+1.0 To +4.5	+1.0 Note 5	40°	
10						500/ 0.95		500/ 0.95	Note 5	−1.0 To +5.0		+0.5 To +4.5	+1.0 Note 5	Unret. 70° Ret. 40°	
11															
12															

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Figure 2–2 (C) (Sheet 3)

External Stores Limitations (F-8 Aircraft)

LINE NUMBER	STATION LOADING AND SUSPENSION					MAXIMUM KIAS OR IMN WHICHEVER IS LESS				ACCELERATION "g"				MAX. DIVE FOR DEL	REMARKS/LIMITATIONS
	STORE	L	LF	RF	R	CARRIAGE	LAUNCH	RELEASE	JETTISON	CARRIAGE	LAUNCH	RELEASE	JETTISON		
1	MK 83 Conical Fin					550/ 1.5		550/ 0.95	550/ 0.95	LBA		+0.5 To +4.5	+0.5 To +4.5	70°	
2						550/ 1.5		550/ 0.95	Note 5	LBA		+0.5 To +4.5	+1.0 Note 5	70°	
3						500/ 1.5		500/ 0.95	Note 5	LBA		0.5 To +4.5	+1.0 Note 5	70°	
4															
5	MK 83 Conical Fin With M-1 Bomb Fuze Extension					475/ 0.95		475/ 0.85	475/ 0.85	0.0 To +4.5		+0.5 To +4.5	+0.5 To +4.5	70°	See note 3. Single release only.
6						475/ 0.95		475/ 0.85	Note 5	0.0 To +4.5		+0.5 To +4.5	+1.0 Note 5	70°	
7						475/ 0.95		475/ 0.85	Note 5	0.0 To +4.5		+0.5 To +4.5	+1.0 Note 5	70°	
8															
9	MK 84 Conical Fin					550/ 1.5		550/ 0.95	550/ 0.95	LBA		+0.5 To +4.5	+0.5 To +4.5	70°	
10															
11															
12															

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Figure 2–2 (Sheet 4)

External Stores Limitations (F-8 Aircraft)

LINE NUMBER	STORE	STATION LOADING AND SUSPENSION L	LF	RF	R	MAXIMUM KIAS OR IMN WHICHEVER IS LESS CARRIAGE	LAUNCH	RELEASE	JETTISON	ACCELERATION "g" CARRIAGE	LAUNCH	RELEASE	JETTISON	MAX. DIVE FOR DEL	REMARKS/LIMITATIONS
1	MK 84 Conical Fin With M-1 Fuze Extension					475/ 0.95		475/ 0.85	475/ 0.85	0.0 To +4.5		+0.5 To +4.5	+0.5 To +4.5	70°	See note 3.
2															
3															
4	MK 86 MK 87 Conical Fin					620/ 1.5		550/ 0.95	550/ 0.95	LBA		+0.5 To +4.5	+0.5 To +4.5	70°	For release from MBR – see note 4. Set MER/TER for RKT NORMAL (single) only. Set pylon SINGLE or DUAL.
5						550/ 1.5		550/ 0.95	Note 5	LBA		+1.0 To +4.5	+1.0 Note 5	40°	
6						550/ 1.1		500	Note 5	LBA		+0.7 To +4.5	Note 5	45°	
7						550/ 1.1		500	Note 5	LBA		+0.7 To +4.5	Note 5	45°	
8	M117A1 with M131A1 Conical Fin					500/ 0.95		525/ 0.95	525/ 0.95	LBA		+0.5 or Greater	+0.5 or Greater	70°	Arrested landings permitted with only one store on TER. Carriage speeds in excess of 500 KIAS may cause conical fin failure. Restrict fin assembly M131A1 to one flight only.
9						500/ 0.95		525/ 0.95	Note 5	LBA		+0.5 or Greater	+1.0 Note 5	70°	
10						500/ 0.95		525/ 0.95	Note 5	LBA		+0.5 or Greater	+1.0 Note 5	70°	
11															
12															

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Figure 2-2 (C) (Sheet 5)

External Stores Limitations (F-8 Aircraft)

LINE NUMBER	STORE	STATION LOADING AND SUSPENSION L	LF	RF	R	MAXIMUM KIAS OR IMN WHICHEVER IS LESS CARRIAGE	LAUNCH	RELEASE	JETTISON	ACCELERATION "g" CARRIAGE	LAUNCH	RELEASE	JETTISON	MAX DIVE FOR DEL	REMARKS/LIMITATIONS
1	MK 88 Conical Fin					550/ 1.5		550/ 0.95	550/ 0.95	LBA		+0.5 To +4.5	+0.5 To +4.5	70°	Set MER/TER for RKT NORMAL (single) only. Set pylon for SINGLE or DUAL.
2						550/ 1.1		500	Note 5	LBA		+0.7 To +4.5	Note 5	45°	
3						550/ 1.1		500	Note 5	LBA		+0.7 To +4.5	Note 5	45°	
4															
5	MK 77 Mod 2 and 4					475/ 0.90		450/ 0.80	450	LBA		+0.5 To +2.5	+0.5 To +2.5	45°	All firebombs not expended must be jettisoned prior to arrested landings and is recommended prior to shore-based landing.
6						475/ 0.90		450/ 0.80	Note 5	LBA		+1.0 To +2.5	+1.0 Note 5	45°	
7						475/ 0.90		450/ 0.80	Note 5	LBA		+1.0 To +2.5	+1.0 Note 5	45°	
8															
9															
10	MK 79 Mod 1					475/ 0.90		450/ 0.80	450/ 0.80	LBA		+0.5 To +2.5	+0.5 To +2.5	40°	All firebombs not expended must be jettisoned prior to arrested landings and is recommended prior to shore-based landing.
11															
12															

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Figure 2-2 (C) (Sheet 6)

External Stores Limitations (F-8 Aircraft)

LINE NUMBER	STORE	STATION LOADING AND SUSPENSION L	LF	RF	R	MAXIMUM KIAS OR IMN WHICHEVER IS LESS CARRIAGE	LAUNCH	RELEASE	JETTISON	ACCELERATION "g" CARRIAGE	LAUNCH	RELEASE	JETTISON	MAX. DIVE FOR DEL	REMARKS/LIMITATIONS
1	MK 76 Mod 4 and 5	✱			✱	LBA		550/ 0.95	Not Recom-mended	LBA		+0.5 To +4.5	Not Recom-mended	70°	See note 2. MER/TER may be substituted for PMBR.
2															
3															
4	CBU-24/B CBU-24/B (MOD) CBU-24A/B CBU-24C/B CBU-29A/B CBU-29/B CBU-29/B (MOD) CBU-49/B CBU-49/B (MOD) CBU-49A/B CBU-49C/B	▮			▮	530/ 1.0		550/ 1.0	550/ 1.0	−0.5 To +5.0 Symmetrical 0.0 To +3.2 Asymmetrical		+0.5 or Greater	+0.5 or Greater	60°	Arrested landings prohibited. Catapult shots prohibited for CBU-24A/B, -29A/B and CBU-49A/B.
5		◆			◆	530/ 1.0		550/ 1.0	Note 5			+0.5 or Greater	Note 5	60°	
6		◆			◆	500/ 1.0		500/ 1.0	Note 5			+0.5 or Greater	Note 5	60°	
7															
8															
9	MK 24 Mod 2A Mod 3 Mod 4	✱			✱	400/ 0.80		400/ 0.80	Note 5	LBA		+1.0	Note 5	Level	Minimum airspeed for release is 350 KIAS. Compliance with Interim Armament Bulletin No. 347 or 494 is mandatory.
10	MK 45 Mod 0	◆			◆	525/ 0.90		525/ 0.90	Note 5	LBA		+1.0	Note 5	Level	
11		◆			◆	525/ 0.90		525/ 0.90	Note 5	LBA		+1.0	Note 5	Level	
12															

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Figure 2-2 (C) (Sheet 7)

External Stores Limitations (F-8 Aircraft)



LINE NUMBER	STORE	STATION LOADING AND SUSPENSION L	LF	RF	R	MAXIMUM KIAS OR IMN WHICHEVER IS LESS CARRIAGE	LAUNCH	RELEASE	JETTISON	ACCELERATION "g" CARRIAGE	LAUNCH	RELEASE	JETTISON	MAX. DIVE FOR DEL	REMARKS/LIMITATIONS
1	MK 89 Mod 0 and 1					LBA		500/ 0.95	Not Recom-mended	LBA		+0.5 To +4.5	Not Recom-mended	70°	See note 2. MER/TER may be substituted for PMBRs. (Requires use of 71125-1 adapter.
2															
3															
4	MK 20 Mod 2 (Rockeye II)					550/ 0.95		475/ 0.90	Note 5	LBA		+0.5 To +4.5	Note 5	60°	Tail fins must be positively armed.
5						550/ 0.95		475/ 0.90	Note 5	LBA		+0.5 To +4.5	Note 5	60°	
6						550/ 0.95		475/ 0.90	Note 5	LBA		+0.5 To +4.5	Note 5	60°	
7															
8															
9	AERO 7D LAU-3A/A LAU-60/A LAU-61/A LAU-69/A					620/ 1.5		500/ 0.95	300-400/ 0.95	LBA		+0.5 To +4.5	+1.0	No Limit	See notes 6, 8 and 9. Jettison empty or full pods. For Aero 7D, LAU-3A/A and LAU-60/A, see note 10.
10						530/ 1.5		500/ 0.95	300-400/ 0.95	LBA		+0.5 To +4.5	+1.0 Note 5	No Limit	
11															
12															

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Figure 2-2 (C) (Sheet 8)

External Stores Limitations (F-8 Aircraft)



LINE NUMBER	STORE	STATION LOADING AND SUSPENSION L	LF	RF	R	MAXIMUM KIAS OR IMN WHICHEVER IS LESS CARRIAGE	LAUNCH	RELEASE	JETTISON	ACCELERATION "g" CARRIAGE	LAUNCH	RELEASE	JETTISON	MAX. DIVE FOR DEL	REMARKS/LIMITATIONS
1	LAU-10A LAU-10A/A					550	550/ 0.95		300– 400/ 0.95	LBA	+0.5 To +4.5		+1.0	No Limit	See notes 6, 8 and 9. Jettison for full or empty pods.
2						550	550/ 0.95		300– 400/ 0.95	LBA	+0.5 To +4.5		+1.0 Note 5	No Limit	
3															
4															
5	AERO 6A 6A-1, 6A-2 LAU-32A/A LAU-32B/A LAU-56/A LAU-68/A					550/ 0.95	500/ 0.95		200– 500/ 0.90	LBA	+0.5 To +4.5		+1.0	No Limit	See notes 6, 8 and 9. Jettison for full or empty pods. For Aero 6A, 6A-1, 6A-2, LAU-32A/A, and LAU-56/A, see note 10.
6						550/ 0.95	500/ 0.95		200– 500/ 0.90	LBA	+0.5 To +4.5		+1.0 Note 5	No Limit	
7															
8															
9	LAU-33A/A LAU-35A/A					LBA	550/ 0.95		Cannot Be Jettisoned	LBA	+0.5 To +4.5		Cannot Be Jettisoned	No Limit	Do not fire above 50,000 feet. For aircraft without AFC 480, when above 15,000 feet, place continuous engine ignition switch on (or manually depress the ignite microswitch) at least 10 seconds prior to firing to prevent possible engine flameout.
10						LBA	550/ 0.95		Cannot Be Jettisoned	LBA	+0.5 To +4.5		Cannot Be Jettisoned	No Limit	
11															
12															

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Figure 2–2 (Sheet 9)

External Stores Limitations (F-8 Aircraft)

LINE NUMBER	STORE	STATION LOADING AND SUSPENSION L	LF	RF	R	MAXIMUM KIAS OR IMN WHICHEVER IS LESS CARRIAGE	LAUNCH	RELEASE	JETTISON	ACCELERATION "g" CARRIAGE	LAUNCH	RELEASE	JETTISON	MAX. DIVE FOR DEL	REMARKS/LIMITATIONS
1	AIM-9B -9C and -9D	AIM-9D authorized with single pylons and LAU-7A or LAU-7A-1 launchers only when wedges defined by NWC China Lake Sketch No. 669996 (Title: Wedge) are utilized. This restriction does not apply when LAU-7A-2 or LAU-7A-3 launchers are used.				LBA	LBA		Same as Launch	LBA	LBA		Same as Launch	No Limit	Do not fire above 65,000 feet. Use military rated thrust for firing 60,000 feet. The minimum airspeed for firing above 50,000 feet is 180 KIAS. For aircraft without AFC 480, when firing above 55,000 feet, place the continuous ignition switch on (or manually depress the ignite microswitch) at least 10 seconds before firing to prevent possible engine flameout. Firing of AIM-9C and -9D missiles from upper right dual pylon station only is permitted for operational necessity because of excessive paint erosion. AERO 3A launcher carries only AIM-9B.
2															
3						LBA	LBA		Same as Launch	LBA	LBA		Same as Launch	No Limit	
4															
5															
6	LAU-24A								Cannot Be Jettisoned				Cannot Be Jettisoned		Used for carriage of AQM-37A missile target. Refer to Supplemental, NATOPS Flight Manual, NAVAIR 01-90HH-1 for operation and limitations.
7															
8															
9	LAU-37A								Cannot Be Jettisoned				Cannot Be Jettisoned		Used for carriage and tow of TDU-22/B and TDU-22A/B targets. Refer to Section VIII of F-8 NATOPS Flight Manual for operation and limitations.
10															
11															
12															

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Figure 2-2 (C) (Sheet 10)

External Stores Limitations (F-8 Aircraft)



LINE NUMBER	STATION LOADING AND SUSPENSION					MAXIMUM KIAS OR IMN WHICHEVER IS LESS				ACCELERATION "g"				MAX. DIVE FOR DEL	REMARKS/LIMITATIONS
	STORE	L	LF	RF	R	CARRIAGE	LAUNCH	RELEASE	JETTISON	CARRIAGE	LAUNCH	RELEASE	JETTISON		
1															
2															
3															
4															
5															
6															
7															
8															
9															
10															
11															
12															

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Figure 2-2 (Sheet 11)

External Stores Limitations (F-8 Aircraft)

NOTES

GENERAL

A. When carrying stores in combination, the more restrictive limits apply.

B. Limits of Basic Aircraft (LBA) are given in figures 2–3 and 2–4. Where an airspeed, Mach number or acceleration is not given, LBA is the restrictive limit for that parameter.

C. Single (rocket normal) or salvo (auto ripple) release modes may be utilized when releasing stores from the MER/TER except when noted in remarks. Dual release from left and right wing stations is permitted in single or salvo mode, unless otherwise noted.

D. Speeds and accelerations listed in the LAUNCH or RELEASE columns are applicable to firing or release of store from its suspension equipment.

E. Ordnance shall be jettisoned above the minimum fragmentation clearance altitude, even though jettison safe is selected.

F. Mixed loads of different stores are not permitted on the same rack.

G. Refer to NAVAIR-11-5A-17 (OP 2216), Part 2, Second Revision, Increment 1 for fuze limitations.

H. No jettison or release testing has been done with wing up/gear down. Jettisoning with aircraft thus configured appears safe but is not recommended except in emergency.

I. The aircraft may undergo a moderate lateral oscillation during weapons release if same number of weapons does not release from each side.

J. Unless otherwise noted, different stores may be loaded on different A/C stations, provided asymmetric limitations are not exceeded.

K. Tests were not conducted to determine minimum release speed, but slower airspeeds appear to effect safer separation, and are valid throughout tactical delivery envelope.

L. Separation characteristics are approximately the same with droop up or down at tactical delivery airspeeds.

M. All stores are cleared for catapult and arrested landings unless otherwise noted.

N. The F-8L has provisions for installing ventral fins and a wing stores system. The flight characteristics and flight limitations necessary to operate with these features have not been published. Wing stores shall not be carried nor ventral fins installed without specific authority from Naval Air Systems Command.

P. The F-8H, F-8J, and F-8K aircraft are authorized to carry all of the external stores listed in this figure. The F-8A and F-8L are authorized to carry only the external stores which operate from single fuselage pylons.

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Figure 2–2 (C) (Sheet 12)

NOTES

SPECIFIC

1. MK 81 bombs with 18-inch extensions can be loaded in tandem on MER or MBR. MK 81 bombs may be loaded aft with 18-inch extensions and forward with 36-inch extensions on MER/MBR.

2. If the TER or PMBR inboard stations are loaded and dual fuselage pylons are installed, the lower missile launcher must not be installed.

3. Limitations shown are for bombs employing 18- or 36-inch bomb fuze extensions. The M-1 bomb fuze extensions are not authorized for carrier based operations or field arrested landings.

4. Only the single release mode on the MBR is authorized.

5. Jettison loaded or unloaded multiple racks in plus 1.0g level flight with the following maximum airspeed restrictions:

   a. MER/MBR loaded with equal number of stores fore and aft, each store weighing 250 pounds or more – 400 KIAS.

   b. TER loaded with any number of stores, except rocket pod(s), each store weighing 250 pounds or more – 400 KIAS.

   c. All other MER/TER/MBR loading conditions and all PMBR loading conditions – 250 KIAS.

   d. If an emergency prevents compliance with the above restrictions, jettison should be performed at slowest practicable airspeed.

   e. Tests have not been conducted to determine minimum jettison speed, but it appears that airspeeds slower than the maximum release speed shown are safer from a separation standpoint.

6. Jettison speeds and accelerations listed in jettisoning columns are for select jettison of rocket pack from TER. Note 5 applies if jettisoning the TER and rocket pack together.

7. Compliance with AAB 357 and 358 is mandatory prior to carriage of this store.

8. Nose fairings may fail at speeds greater than 450 KIAS resulting in increased drag and fuel consumption.

9. Rocket launcher arrestment restrictions promulgated by IAAB 394 (current revision) must be complied with.

10. Jettison launcher when carrying live or inert warheads whether or not a firing attempt has been made when a carrier or field arrestment is anticipated.

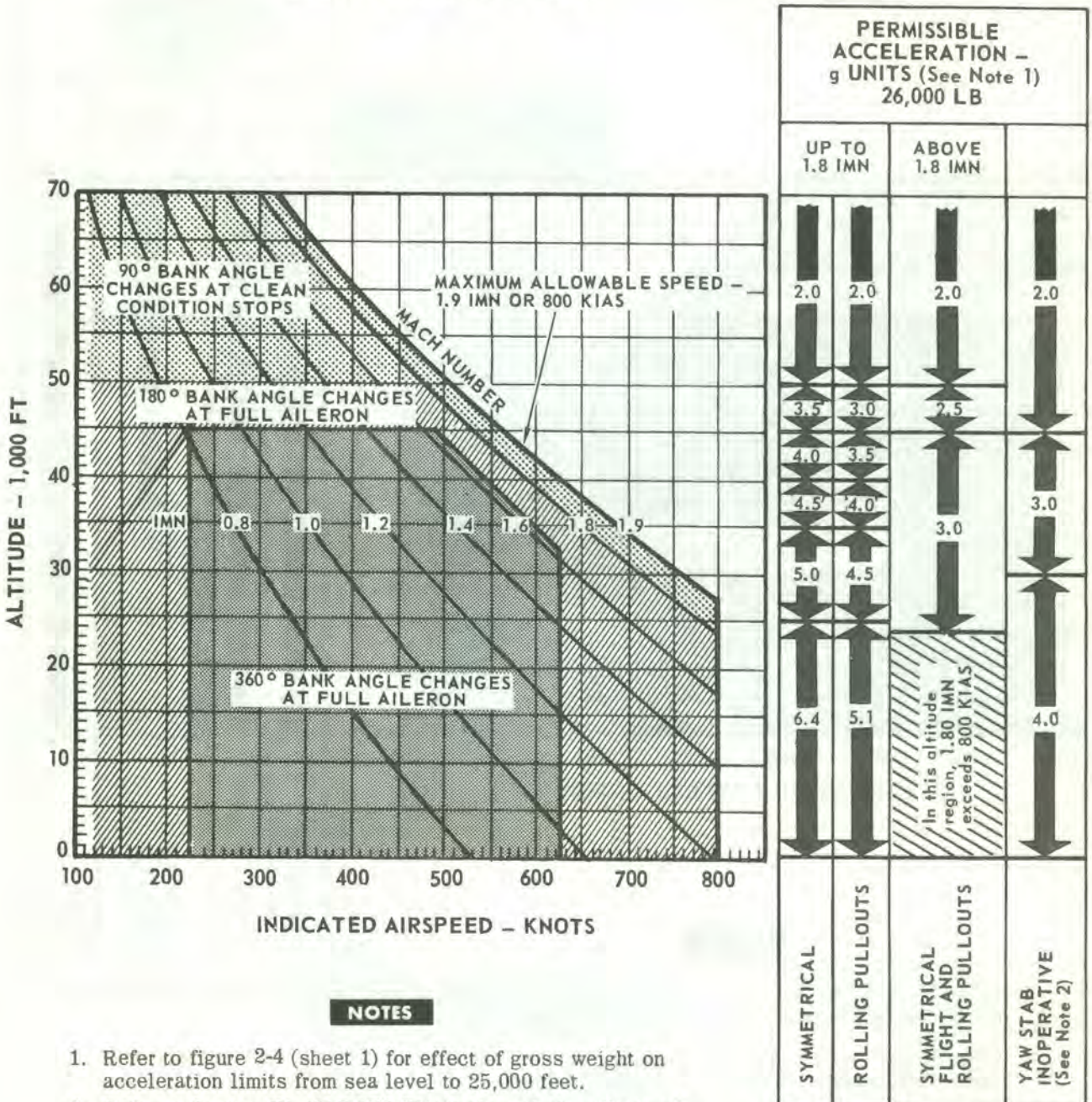
11. NOTE 11 IS ADDED IN FRONT OF MANUAL (INT. CHG. 25)

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Figure 2-2 (C) (Sheet 13)

Flight Operating Limitations

F-8D and H – AIRPLANE WITHOUT WING STORES, WITH OR WITHOUT FUSELAGE STORES (See Notes 3 and 4)



NOTES

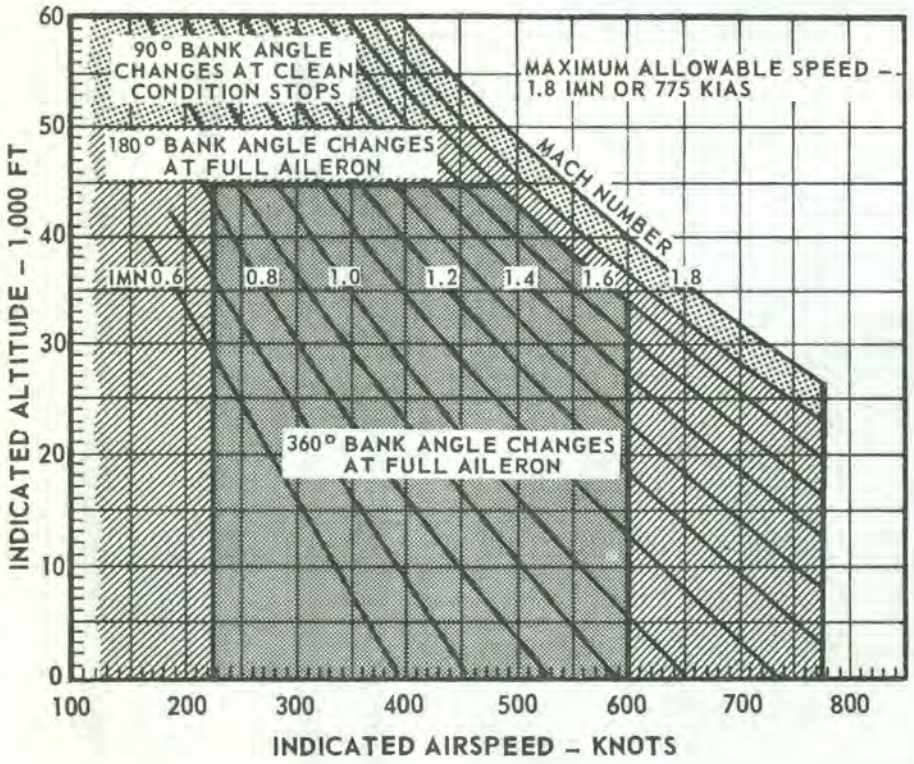
1. Refer to figure 2-4 (sheet 1) for effect of gross weight on acceleration limits from sea level to 25,000 feet.
2. Refer to Section IV, NATOPS Flight Manual, for effects of yaw stabilization failure on flight characteristics.
3. Refer to figure 2-5 for additional limitations when carrying AIM-9B missile with MK-8 warhead.
4. F-8H may be configured with wing pylons and unloaded Aero 7A-1 bomb racks.

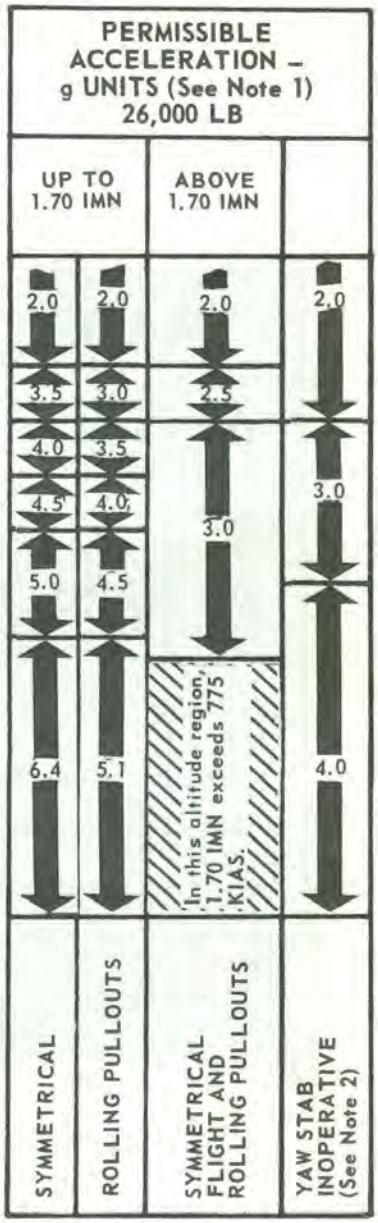
AZ-227(1)-1-68

Figure 2–3 (Sheet 1)

Flight Operating Limitations

F-8E and J – AIRPLANE WITHOUT WING STORES, WITH OR WITHOUT FUSELAGE STORES (See Notes 3 and 4)





NOTES

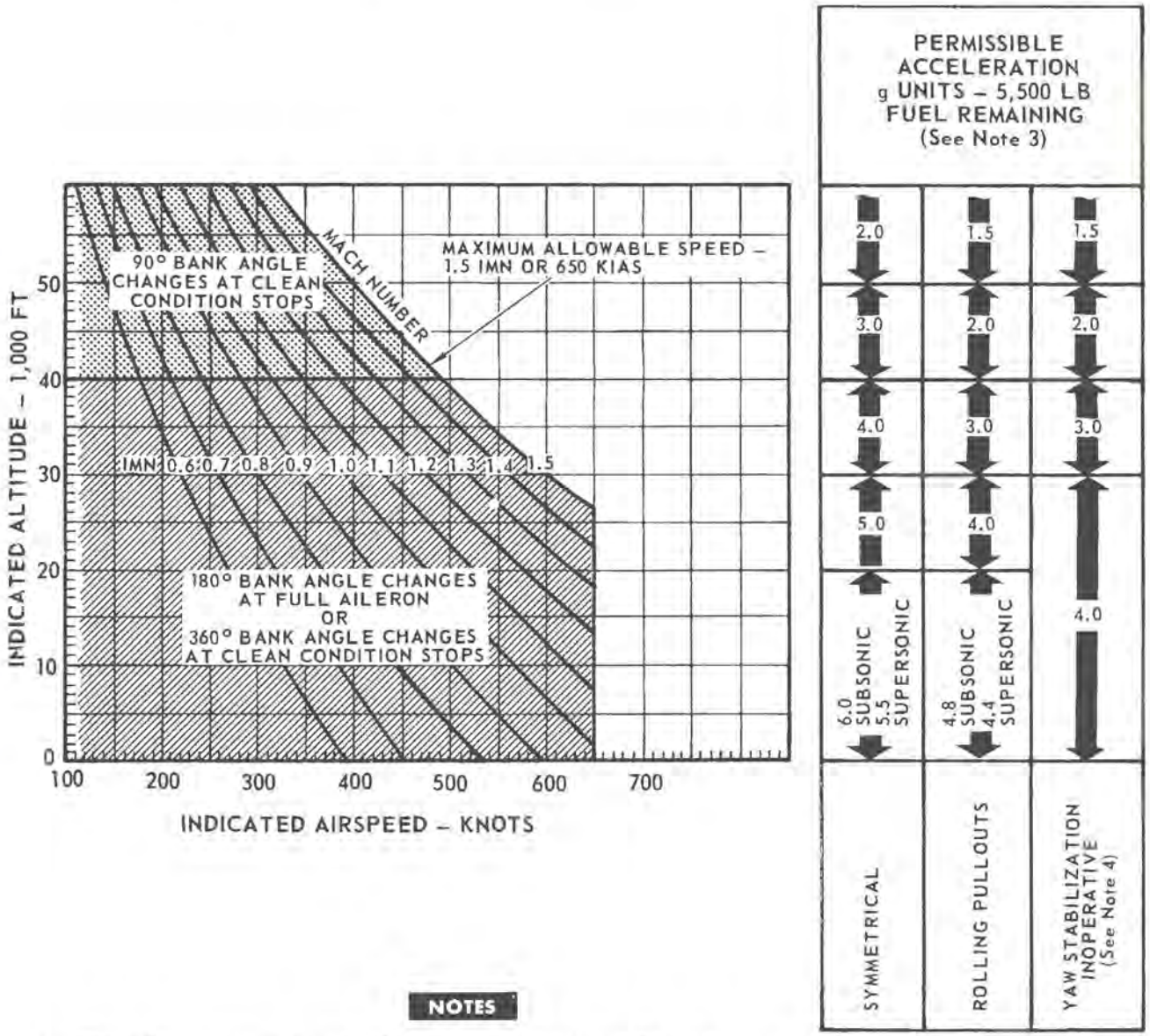
1. Refer to figure 2-4 (sheet 1) for effect of gross weight on acceleration limits from sea level to 25,000 feet.
2. Refer to Section IV, NATOPS Flight Manual, for effects of yaw stabilization failure on flight characteristics.
3. Refer to figure 2-5 for additional limitations when carrying AIM-9B missile with MK-8 warhead.
4. Airplane may be configured with wing pylons and unloaded Aero 7A-1 bomb racks.

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Figure 2–3 (Sheet 2)

Flight Operating Limitations

F-8E – AIRPLANE WITH WING STORES
WITH OR WITHOUT FUSELAGE STORES
(See Notes 1 and 2)



NOTES

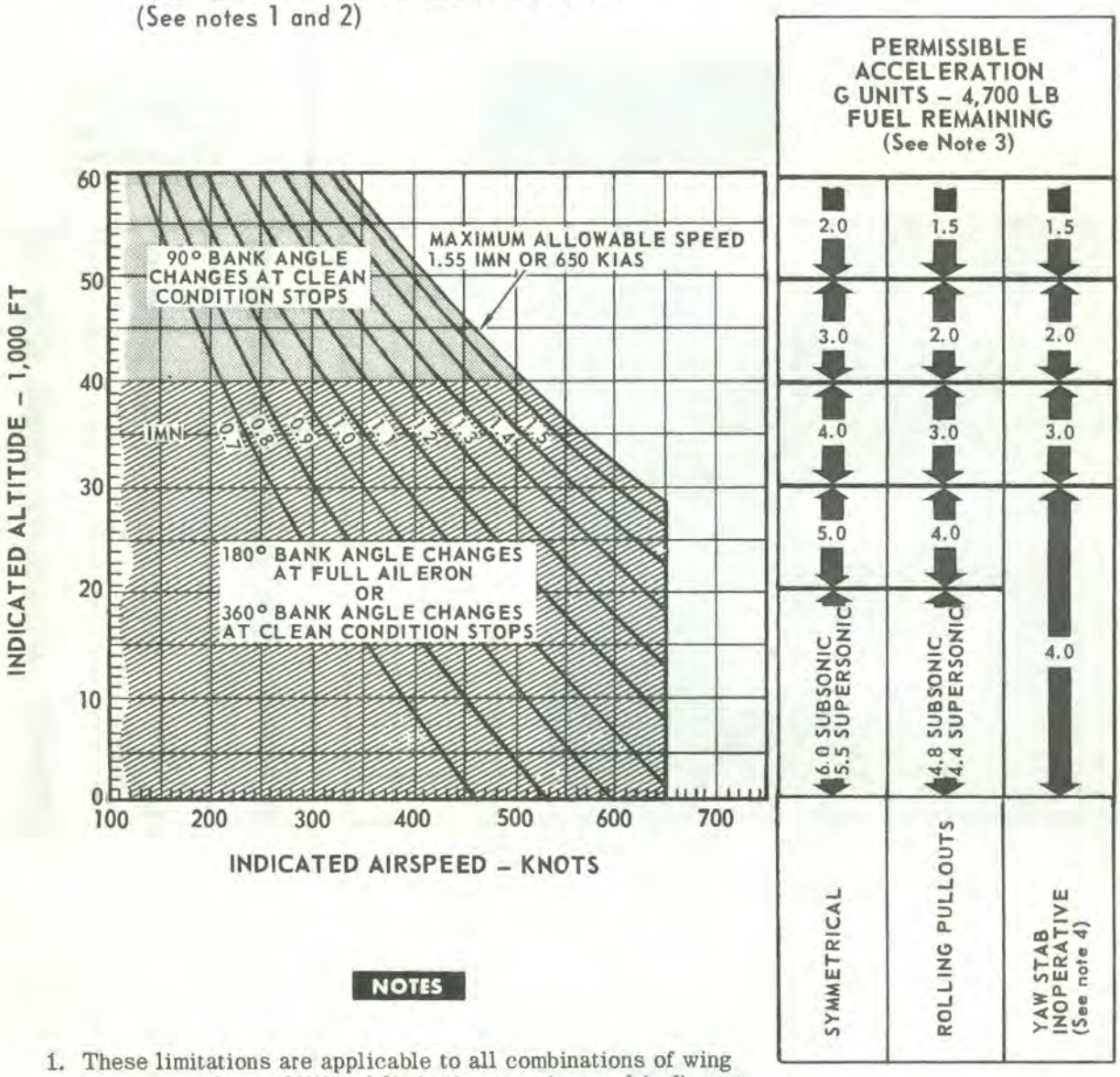
1. These limitations are applicable to all combinations of wing armament unless additional limitations are imposed in figures 2-2 and 2-5.
2. Restrictions of Figure 2-3 (Sheet 2) apply with wing pylons and unloaded Aero 7A-1 bomb racks installed. Rocket launchers and multiple bomb racks are considered to be wing stores.
3. Refer to figure 2-4 (sheet 3) for effect of fuel remaining (gross weight) on acceleration limits.
4. Refer to Section IV, NATOPS Flight Manual, for effects of yaw stabilization failure.

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Figure 2–3 (Sheet 3)

Flight Operating Limitations

F-8H – AIRPLANE WITH WING STORES,
WITH OR WITHOUT FUSELAGE STORES
(See notes 1 and 2)



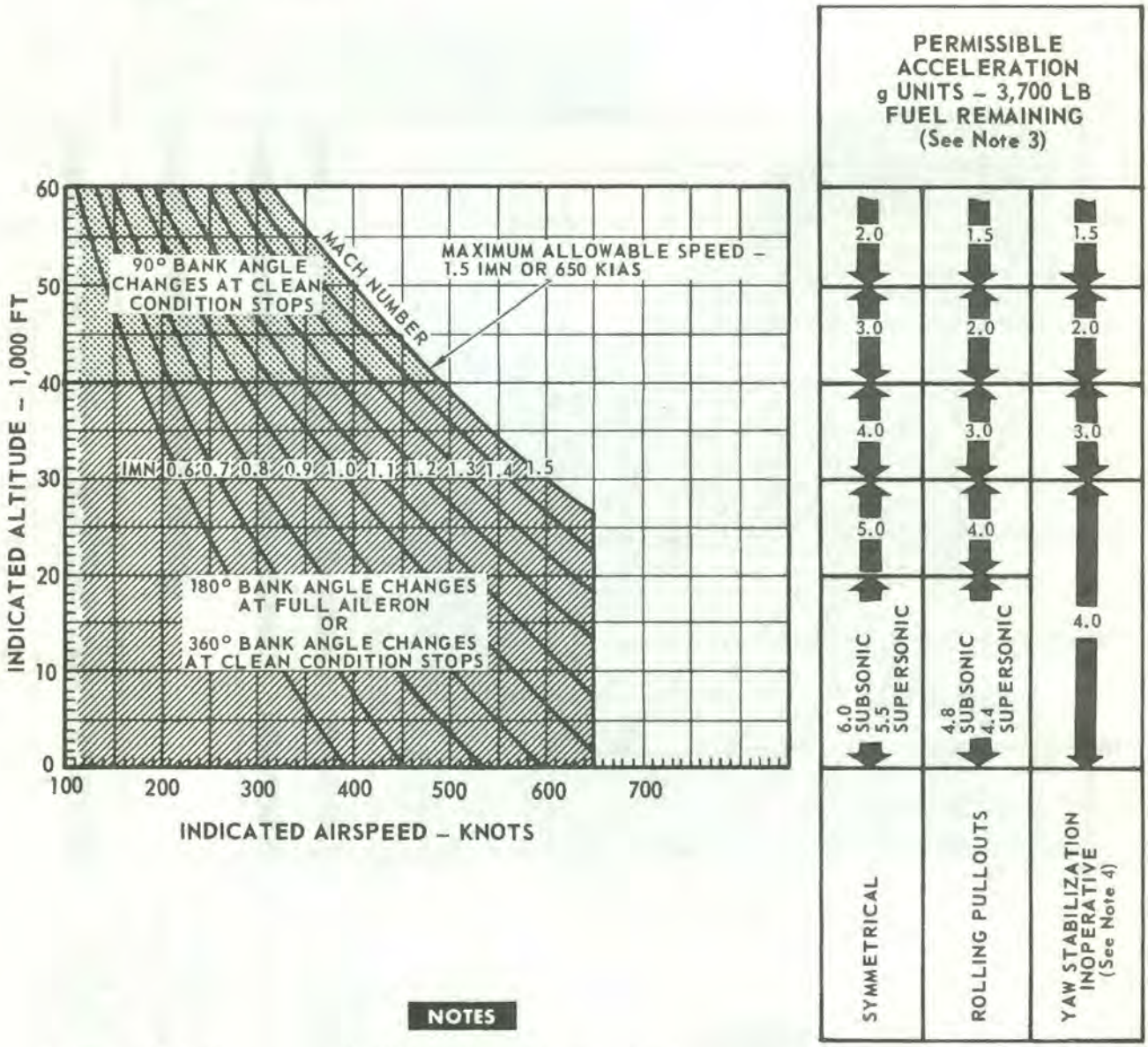
NOTES

1. These limitations are applicable to all combinations of wing armament unless additional limitations are imposed in figures 2-2 and 2-5.
2. Restrictions of figure 2-3 (Sheet 1) apply for aircraft configured with wing pylons and unloaded Aero 7A-1 bomb racks. Rocket launchers and multiple bomb racks are considered to be wing stores.
3. Refer to figure 2-4 (Sheet 4) for effect of fuel remaining (gross weight) on acceleration limits.
4. Refer to Section IV, NATOPS Flight Manual, for effects of yaw stabilization failure.

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Figure 2–3 (Sheet 4)

F-8J – AIRPLANE WITH WING STORES
WITH OR WITHOUT FUSELAGE STORES
(See Notes 1 and 2)



NOTES

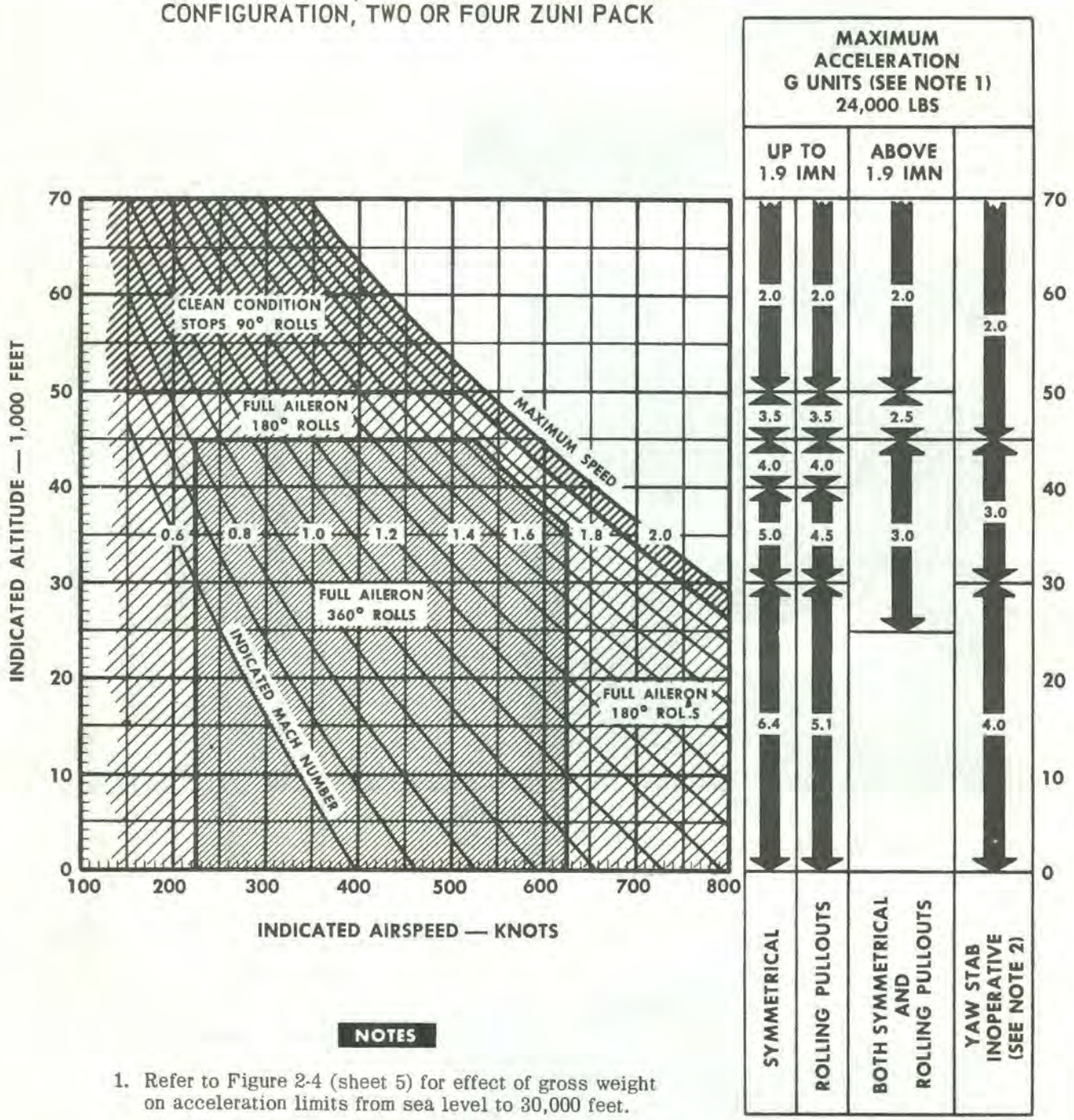
1. These limitations are applicable to all combinations of wing armament unless additional limitations are imposed in figures 2-2 and 2-5.
2. Restrictions of Figure 2-3 (Sheet 2) apply with wing pylons and unloaded Aero 7A-1 bomb racks installed. Rocket launchers and multiple bomb racks are considered to be wing stores.
3. Refer to figure 2-4 (sheet 4A) for effect of fuel remaining (gross weight) on acceleration limits.
4. Refer to Section IV, NATOPS Flight Manual, for effects of yaw stabilization failure.

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Figure 2–3 (Sheet 5)

Flight Operating Limitations

F-8C - ORIGINAL AIRSPEED SYSTEM (BEFORE ASC 335)
BASIC AIRPLANE, TWO OR FOUR SIDEWINDER
CONFIGURATION, TWO OR FOUR ZUNI PACK



NOTES

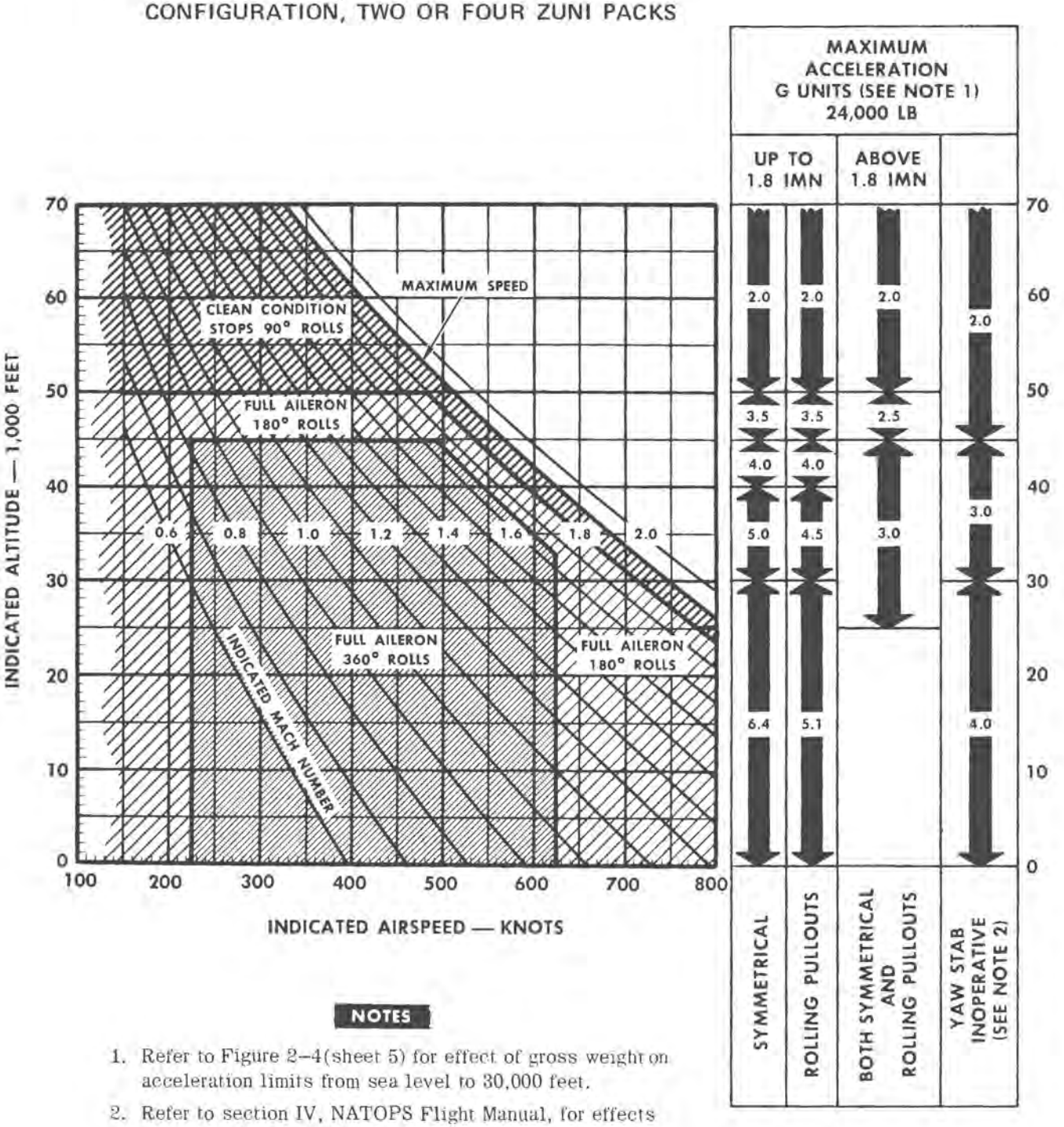
1. Refer to Figure 2-4 (sheet 5) for effect of gross weight on acceleration limits from sea level to 30,000 feet.
2. Refer to section IV, NATOPS Flight Manual, for effects of yaw-stabilization failure on flight characteristics.
3. Refer to Figure 2-5 for airspeed limitations when carrying Sidewinder AIM-9B missile with MK-8 warhead.

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Figure 2-3 (Sheet 6)

Flight Operating Limitations

F-8C (AFTER ASC 335), ALL F-8K –
BASIC AIRPLANE, TWO OR FOUR SIDEWINDER
CONFIGURATION, TWO OR FOUR ZUNI PACKS



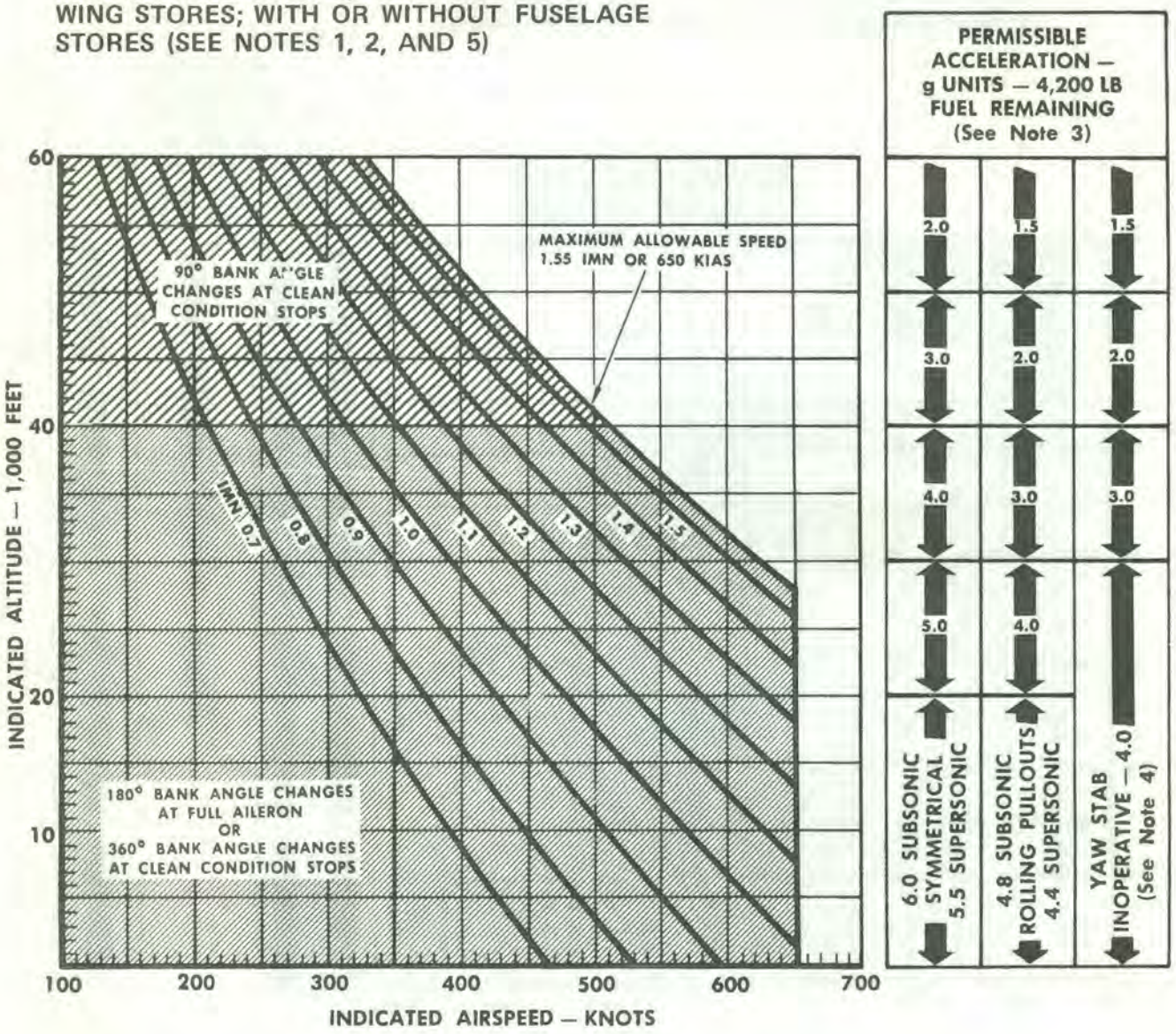
NOTES

1. Refer to Figure 2–4 (sheet 5) for effect of gross weight on acceleration limits from sea level to 30,000 feet.
2. Refer to section IV, NATOPS Flight Manual, for effects of yaw-stabilization failure on flight characteristics.
3. Refer to Figure 2–5 for airspeed limitations when carrying Sidewinder AIM-9B missile with MK 8 warhead.

Figure 2–3 (Sheet 7)

Flight Operating Limitations

F-8C (AFTER ASC 335), ALL F-8K – WITH WING STORES; WITH OR WITHOUT FUSELAGE STORES (SEE NOTES 1, 2, AND 5)



NOTES

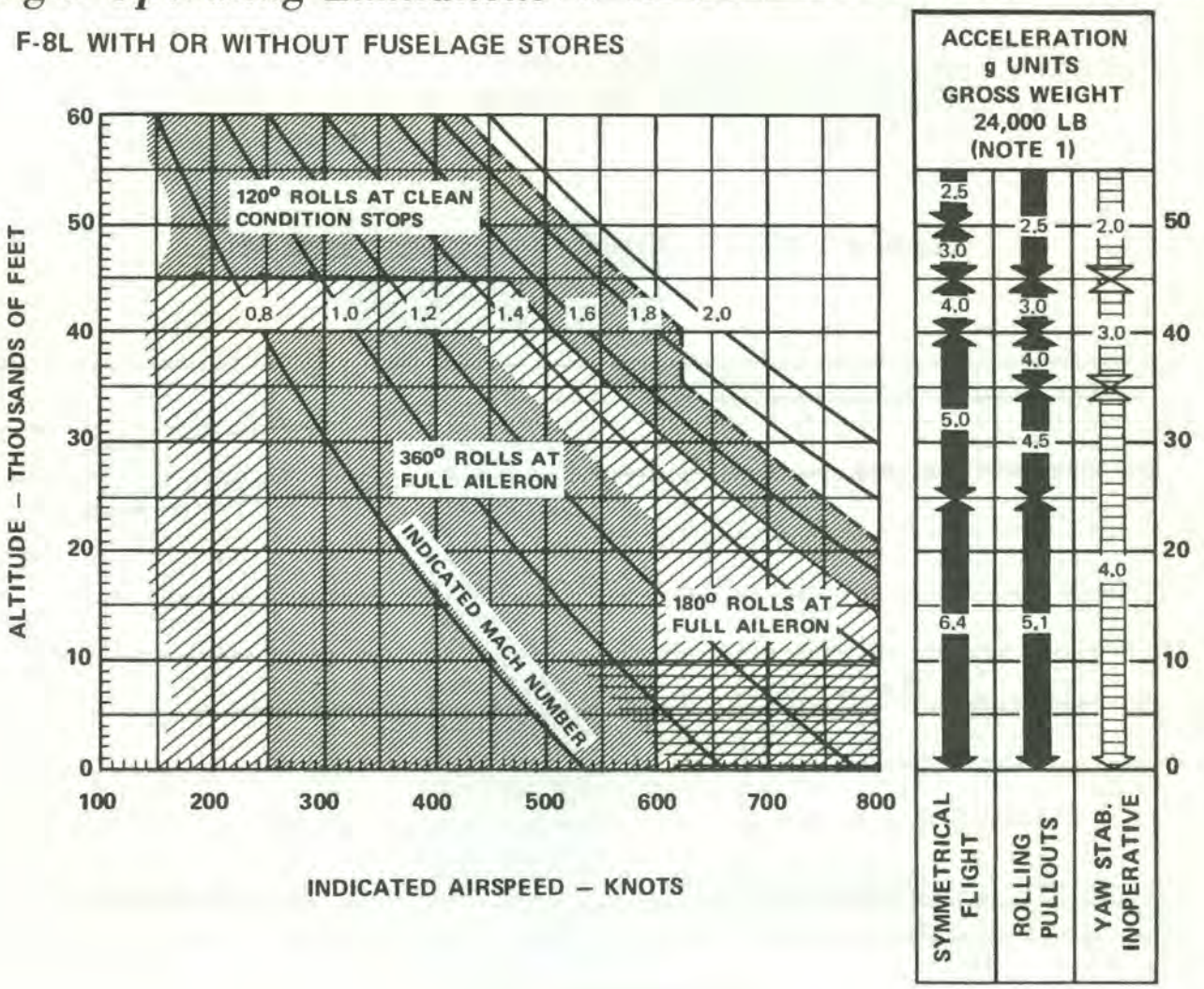
1. These limitations are applicable to all combinations of wing armament unless additional limitations are imposed in Figure 2-2 and 2-5.
2. Basic aircraft restrictions apply with wing pylons and Aero 7A-1 bomb racks installed. Rocket launchers or packs and multiple bomb racks are considered to be wing stores.
3. Refer to Figure 2-4(sheet 6) for effect of fuel remaining (gross weight) on acceleration limits.
4. Refer to section IV, NATOPS Flight Manual for effects of yaw-stabilization failure.
5. Use figure 11-1 NATOPS Flight Manual to determine the corresponding flight operating limitations for airplanes with the original airspeed system (before ASC 335).

AZ-257-03-69

Figure 2–3 (Sheet 8)

Flight Operating Limitations

F-8L WITH OR WITHOUT FUSELAGE STORES



FLIGHT PROHIBITED WHEN AIRCRAFT RUN OUT OF TRIM

MAXIMUM PERMISSIBLE SPEED

MAXIMUM PERMISSIBLE POSITIVE ACCELERATION

MAXIMUM PERMISSIBLE POSITIVE ACCELERATION – YAW STAB INOPERATIVE

NOTES

1. Refer to figure 2-4 (sheet 7) for effect of gross weight on acceleration limitations.
2. Refer to section IV, NATOPS Flight Manual, for effects of yaw stabilization failure on flight characteristics.
3. Refer to figure 2-5 for airspeed limitations when carrying Sidewinder missile with Mk 8 warhead.

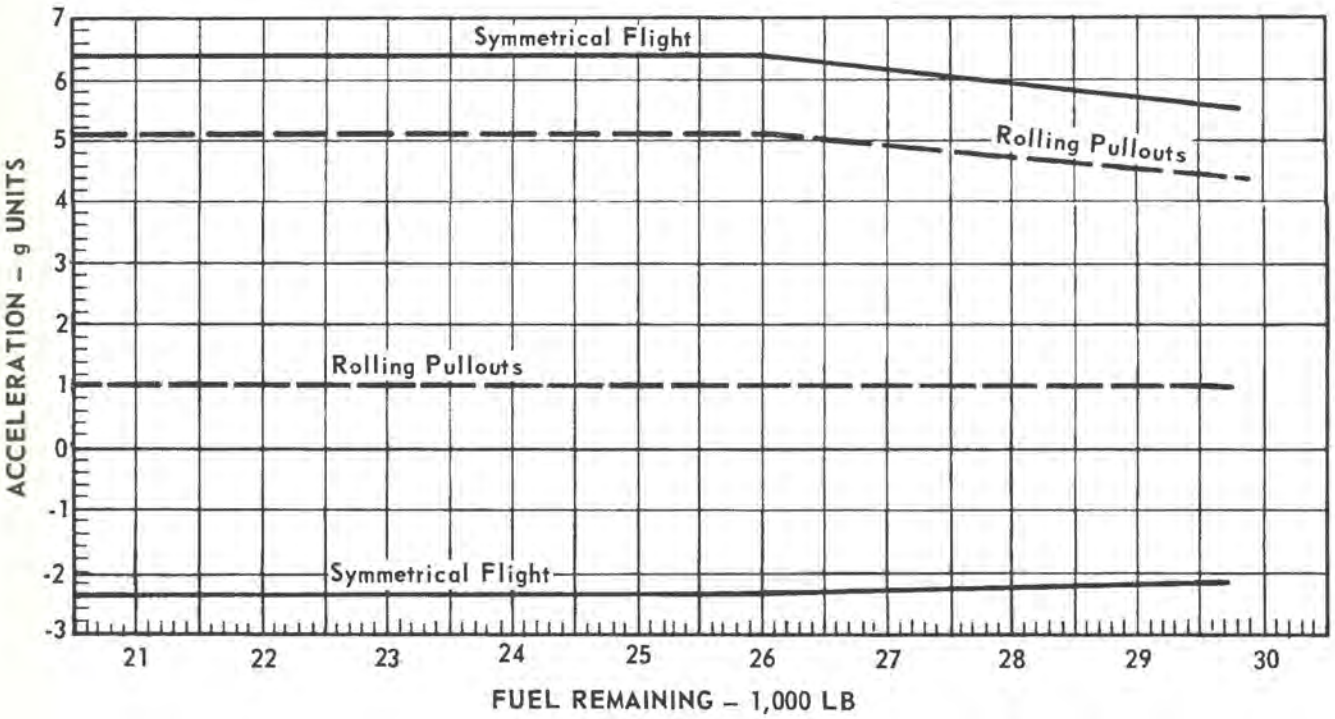
AZ-315-1-69

Figure 2–3 (Sheet 9)

Acceleration Limits

F-8D/E/H/J – AIRPLANES WITHOUT WING STORES
WITH OR WITHOUT FUSELAGE STORES
(See Note 1)

CLEAN AND CRUISE CONDITION – SEA LEVEL TO 25,000 FT



NOTES

1. Airplanes may be configured with wing pylons and unloaded Aero 7A-1 bomb racks.
2. Aileron rolls shall not be initiated at less than 1.0g. During rolls the stick shall not be moved forward of the level flight longitudinal stick position for the entry airspeed used.

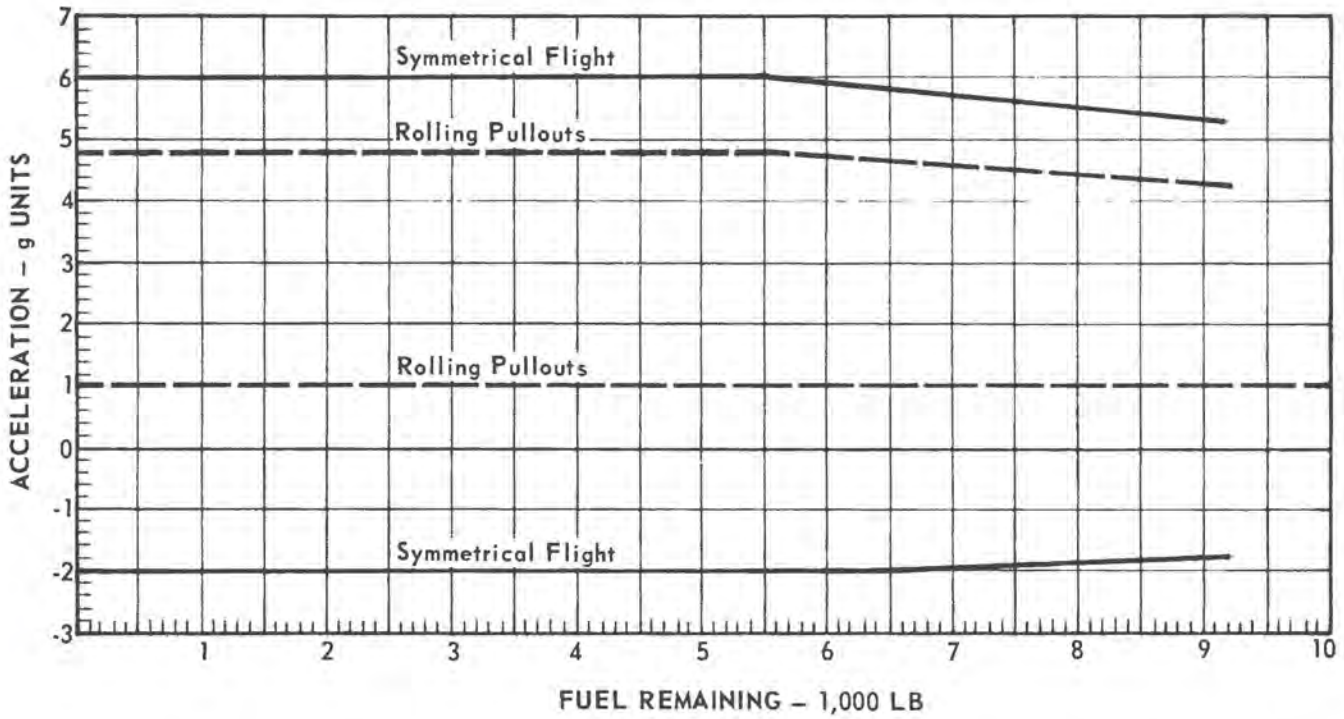
AZ-228(1)-1-68

Figure 2–4 (Sheet 1)

Acceleration Limits

F-8E – AIRPLANE WITH WING STORES,
WITH OR WITHOUT FUSELAGE STORES
(See Note 2)

CLEAN AND CRUISE CONDITION – SEA LEVEL TO 20,000 FT
SUBSONIC FLIGHT



NOTES

1. Aileron rolls shall not be initiated at less than 1.0g. During rolls the stick shall not be moved forward of the level flight longitudinal stick position for the entry airspeed used.
2. Restrictions of Figure 2-4(sheet 1) apply for airplanes configured with wing pylons and unloaded Aero 7A-1 bomb racks. Rocket launchers and multiple bomb racks are considered to be wing stores.

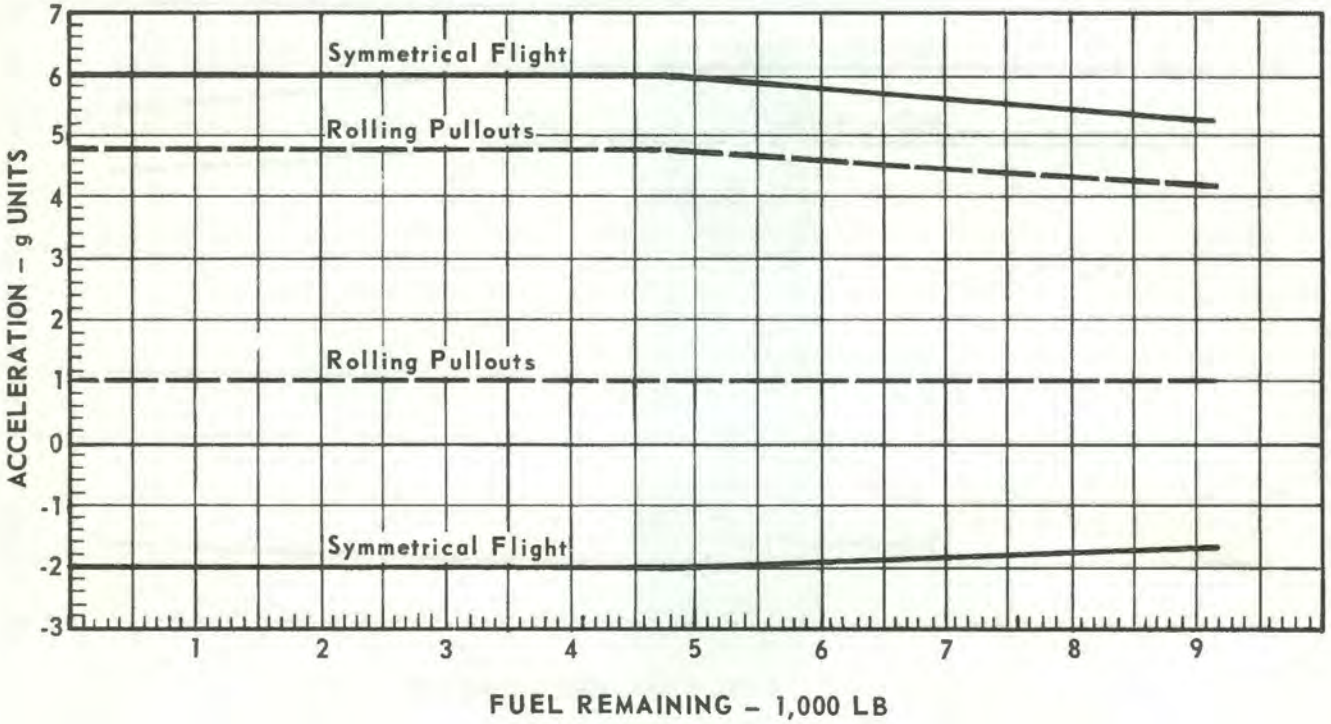
AZ-228(1)-6 68

Figure 2–4 (Sheet 2)

Acceleration Limits

F-8H – AIRPLANE WITH WING STORES, WITH OR WITHOUT FUSELAGE STORES (See Note 2)

CLEAN AND CRUISE CONDITION – SEA LEVEL TO 20,000 FT SUBSONIC FLIGHT



NOTES

1. Aileron rolls shall not be initiated at less than 1.0g. During rolls the stick shall not be moved forward of the level flight longitudinal stick position for the entry airspeed used.
2. Restrictions of Figure 2–4 (sheet 1) apply for airplane configured with wing pylons and unloaded Aero 7A-1 bomb racks. Rocket launchers and multiple bomb racks are considered to be wing stores.

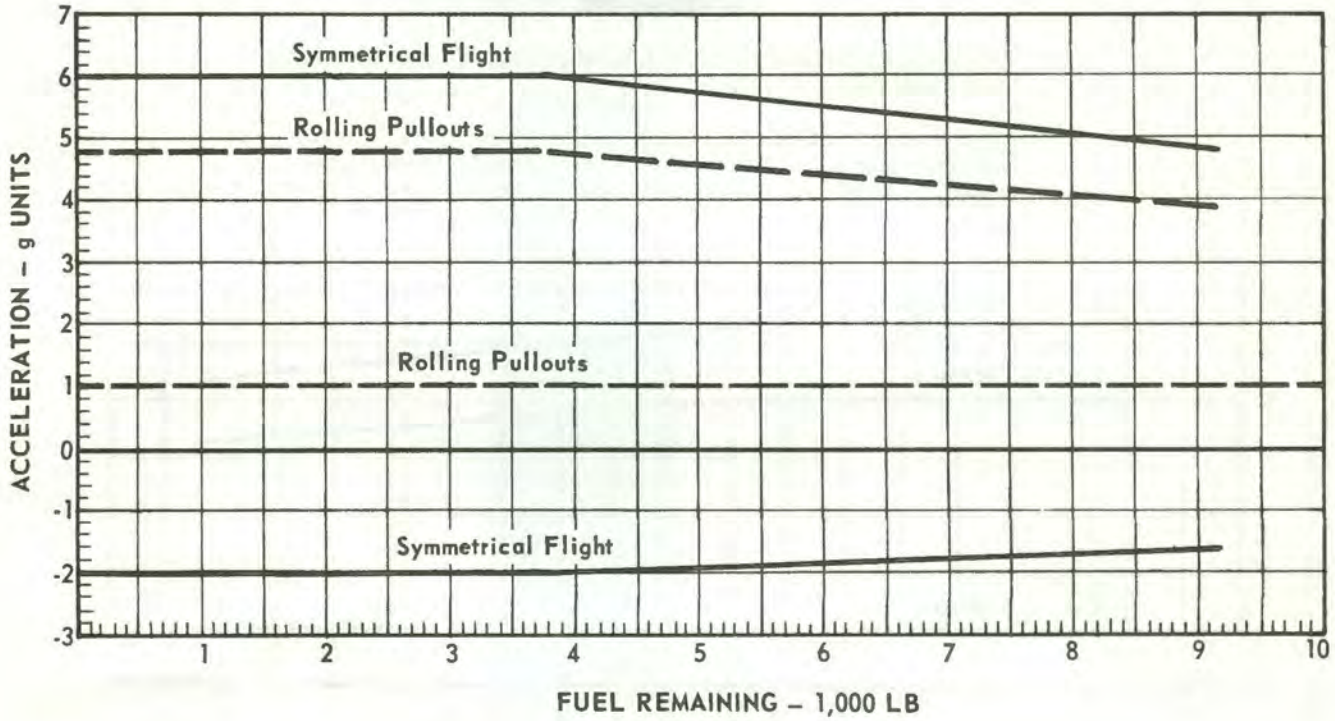
AZ-228(4)-6-68

Figure 2–4 (Sheet 3)

Acceleration Limits

F-8J – AIRPLANE WITH WING STORES,
WITH OR WITHOUT FUSELAGE STORES
(See Note 2)

CLEAN AND CRUISE CONDITION – SEA LEVEL TO 20,000 FT
SUBSONIC FLIGHT



NOTES

1. Aileron rolls shall not be initiated at less than 1.0g. During rolls the stick shall not be moved forward of the level flight longitudinal stick position for the entry airspeed used.
2. Restrictions of figure 2-3 (sheet 1) apply for airplanes configured with wing pylons and unloaded Aero 7A-1 bomb racks. Rocket launchers and multiple bomb racks are considered to be wing stores.

AZ-228(4A)-1-68

Figure 2–4 (Sheet 4)

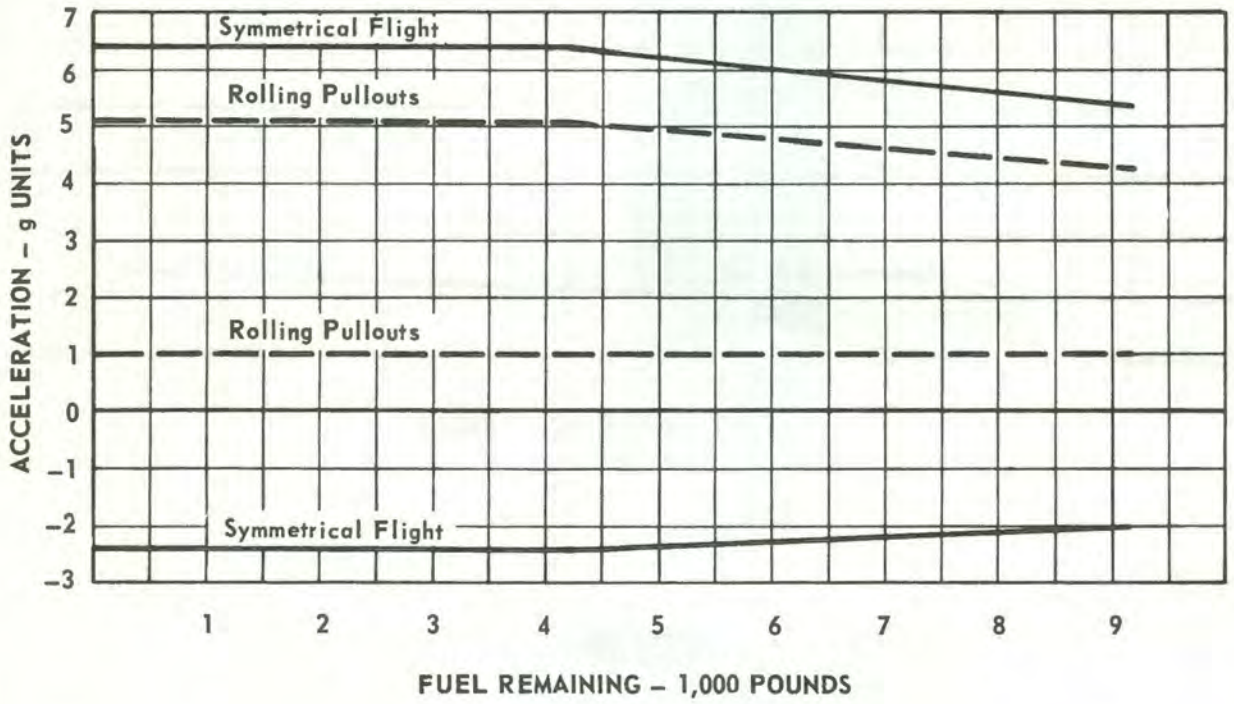
Acceleration Limits

F-8C, F-8K – AIRPLANES WITHOUT WING STORES (WITH OR WITHOUT FUSELAGE STORES)

CLEAN AND CRUISE CONDITION – S.L. TO 30,000 FEET

NOTES

1. Airplane may be configured with wing pylons and unloaded Aero 7A-1 bomb racks.
2. Aileron rolls shall not be initiated at less than 1.0 g. During rolls the stick shall not be moved forward of the level flight longitudinal stick position for the entry airspeed used.



AZ-258-03-69

Figure 2–4 (Sheet 5)

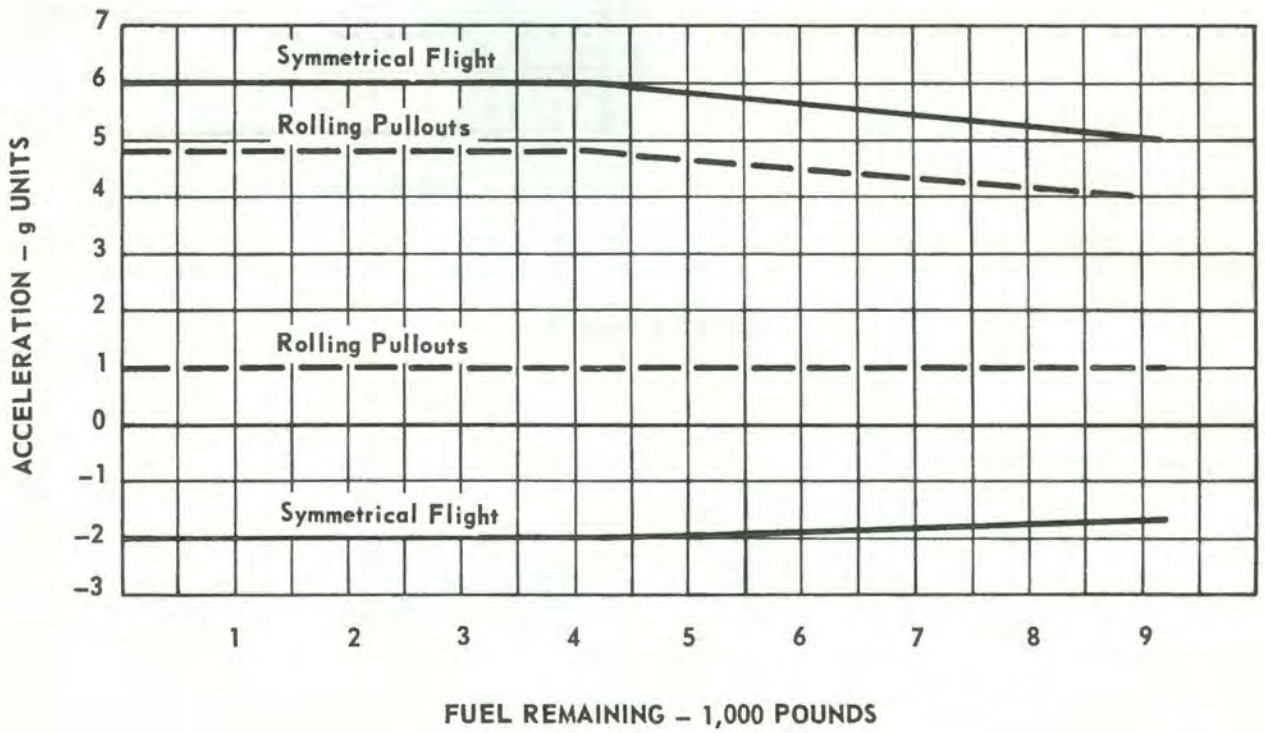
Acceleration Limits

F-8C, F-8K – AIRPLANES WITH WING STORES (WITH OR WITHOUT FUSELAGE STORES)

CLEAN AND CRUISE CONDITION – S.L. TO 20,000 FEET SUBSONIC FLIGHT

NOTE

1. Aileron rolls shall not be initiated at less than 1.0 g. During rolls the stick shall not be moved forward of the level flight longitudinal stick position for the entry airspeed used.
2. Restrictions of figure 2-3 (sheet 5) apply for airplanes configured with wing pylons and unloaded Aero 7A-1 bomb racks. Rocket launchers and multiple bomb racks are considered to be wing stores.



AZ-259-03-69

Figure 2–4 (Sheet 6)

Acceleration Limits

F-8L – WITH OR WITHOUT FUSELAGE STORES

NOTE

Aileron rolls shall not be initiated at less than 1g, and during rolls the stick shall not be moved forward of the level flight longitudinal stick position for the entry airspeed used.

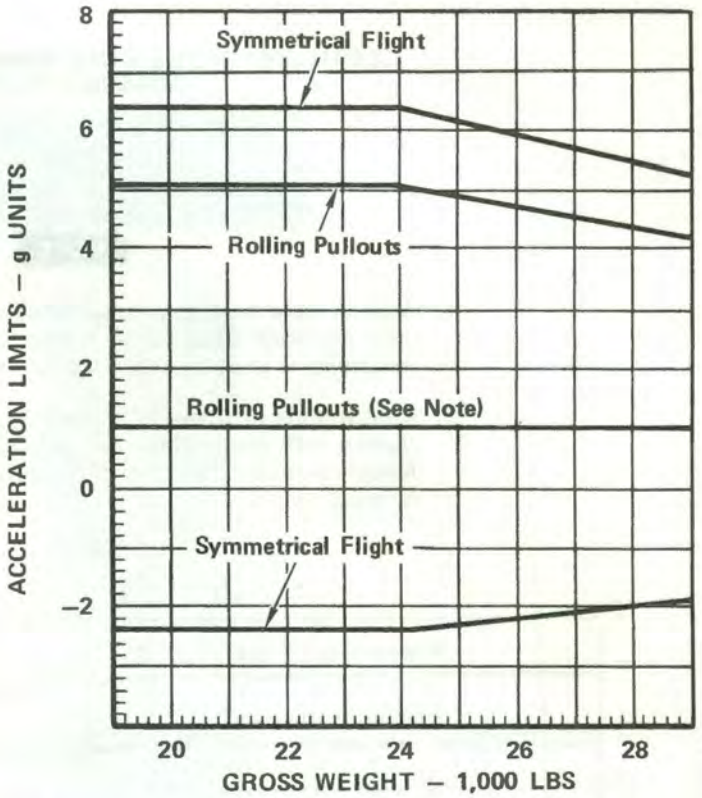
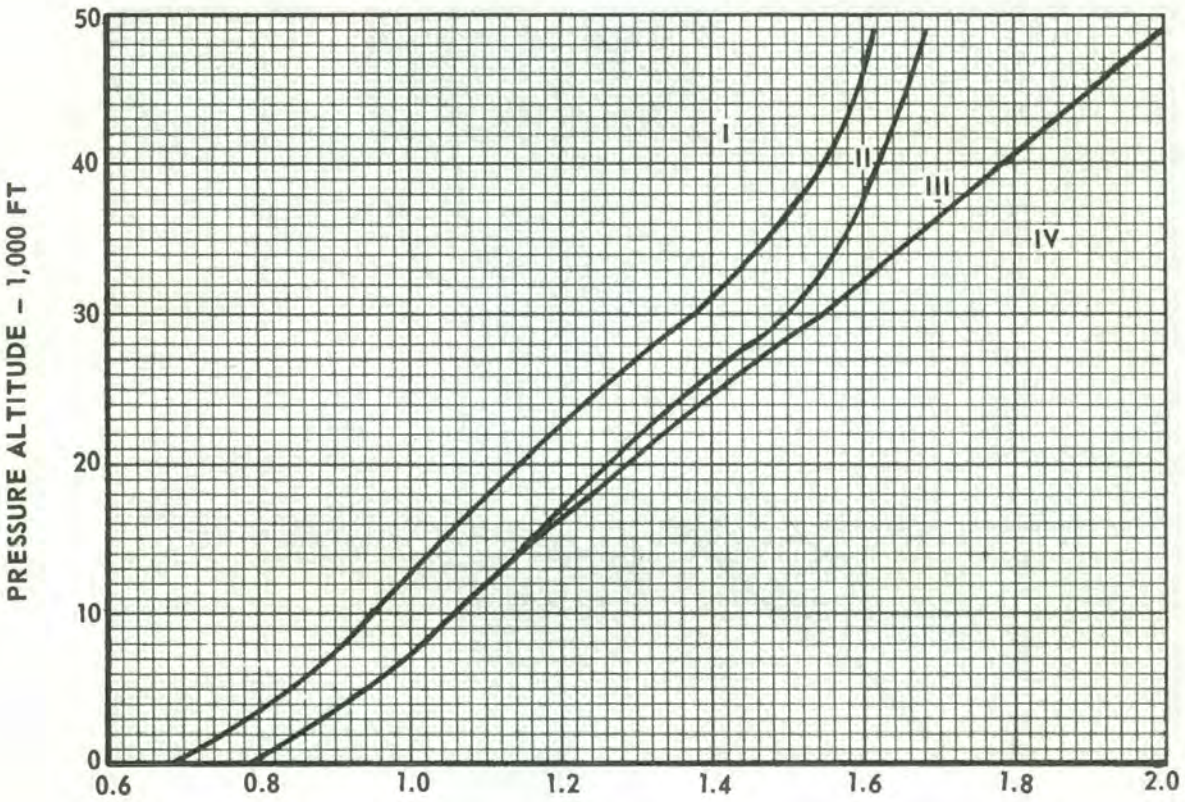


Figure 2–4 (Sheet 7)

Airspeed Limitations

AIRCRAFT CARRYING AIM-9B
MISSILE(S) WITH MK 8 MOD 0/1/2
WARHEAD HOT DAY – 103°F
(39.5°C) AT SEA LEVEL



LIMITATIONS

ZONE I:	No restrictions
ZONE II:	Repeated excursions of no more than 10 minutes each permissible
ZONE III:	Repeated excursions of no more than 5 minutes each permissible; inspection of warheads recommended after each excursion into Zones II and III.
ZONE IV:	Avoid

NOTES

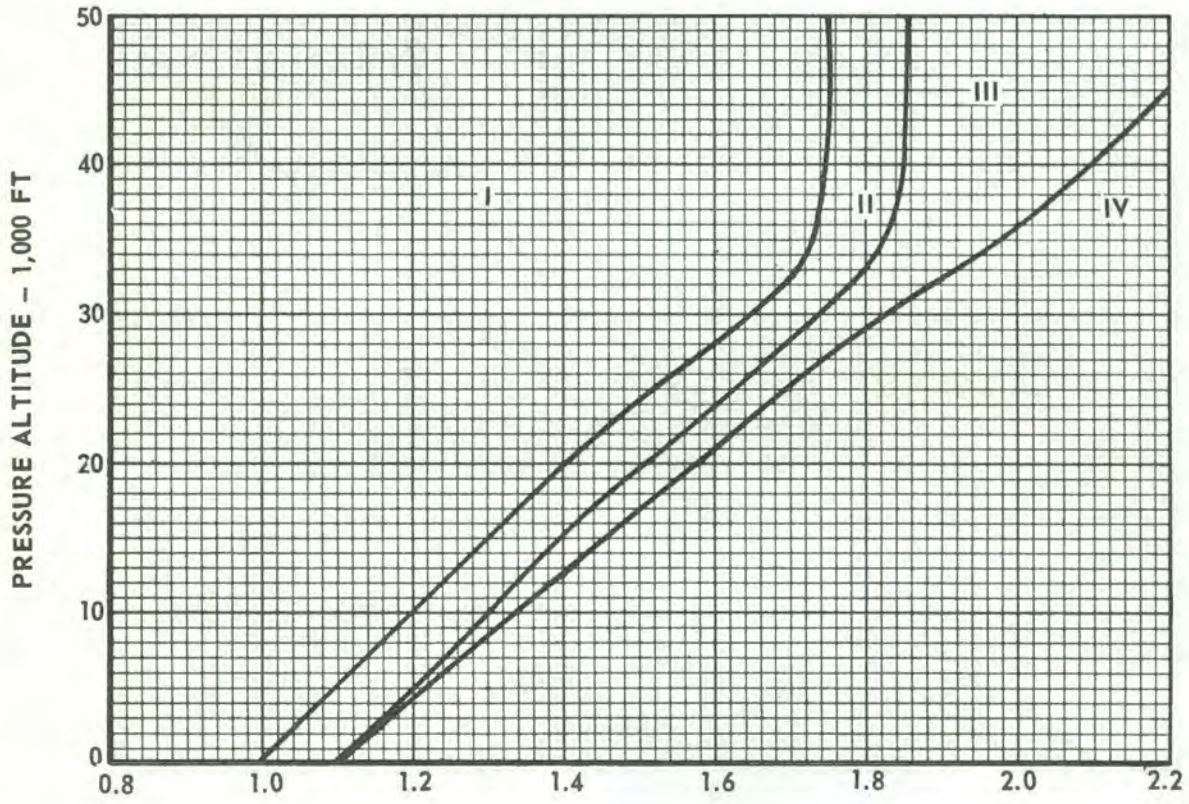
1. Limitations do not apply to aircraft climb schedules.
2. If limitations of Zones II, III and IV are violated, the warhead should be destroyed by jettisoning the missile, if possible. If not possible, landing on the carrier or airstrip can be made with low order risk.
3. Limitations apply only to the Mk 8 Mod 0/1/2 warhead. The Mk 8 Mod 3 warhead is unrestricted.

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Figure 2–5 (Sheet 1)

Airspeed Limitations

AIRCRAFT CARRYING AIM-9B
MISSILE(S) WITH MK 8 MOD 0/1/2
WARHEAD STANDARD DAY –
59°F (15°C) AT SEA LEVEL



LIMITATIONS

ZONE I:	No restrictions
ZONE II:	Repeated excursions of no more than 10 minutes each permissible
ZONE III:	Repeated excursions of no more than 5 minutes each permissible; inspection of warheads recommended after each excursion into Zones II and III.
ZONE IV:	Avoid

NOTES

1. Limitations do not apply to aircraft climb schedules.
2. If limitations of Zones II, III and IV are violated, the warhead should be destroyed by jettisoning the missile, if possible. If not possible, landing on carrier or airstrip can be made with low order risk.
3. Limitations apply only to the Mk 8 Mod 0/1/2 warhead. The Mk 8 Mod 3 warhead is unrestricted.

AZ-229(2)-6-67

Figure 2–5 (Sheet 2)

Pylons, Racks and Weapons Compatibility

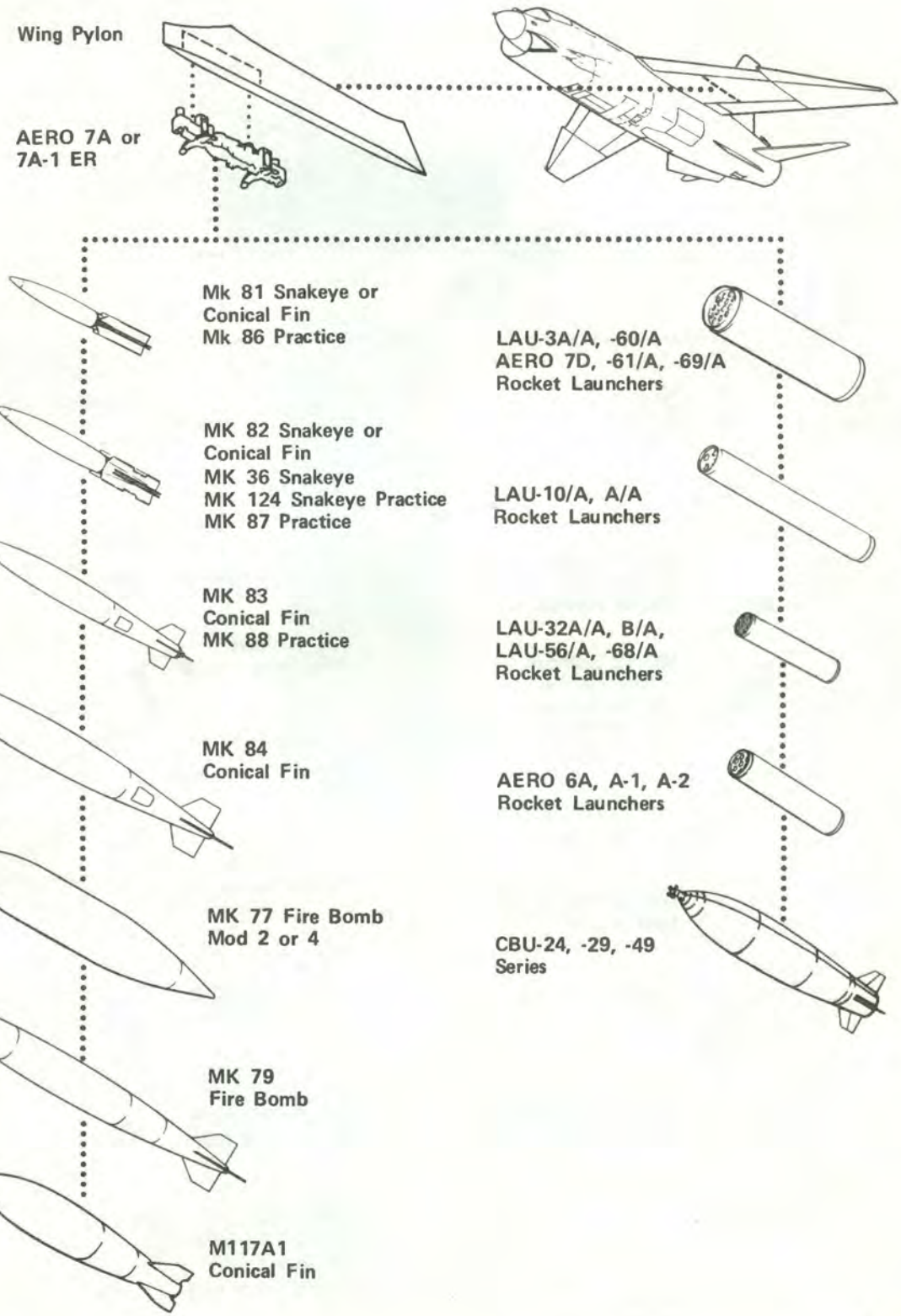


Figure 2–6 (U) (Sheet 1)

Pylons, Racks and Weapons Compatibility

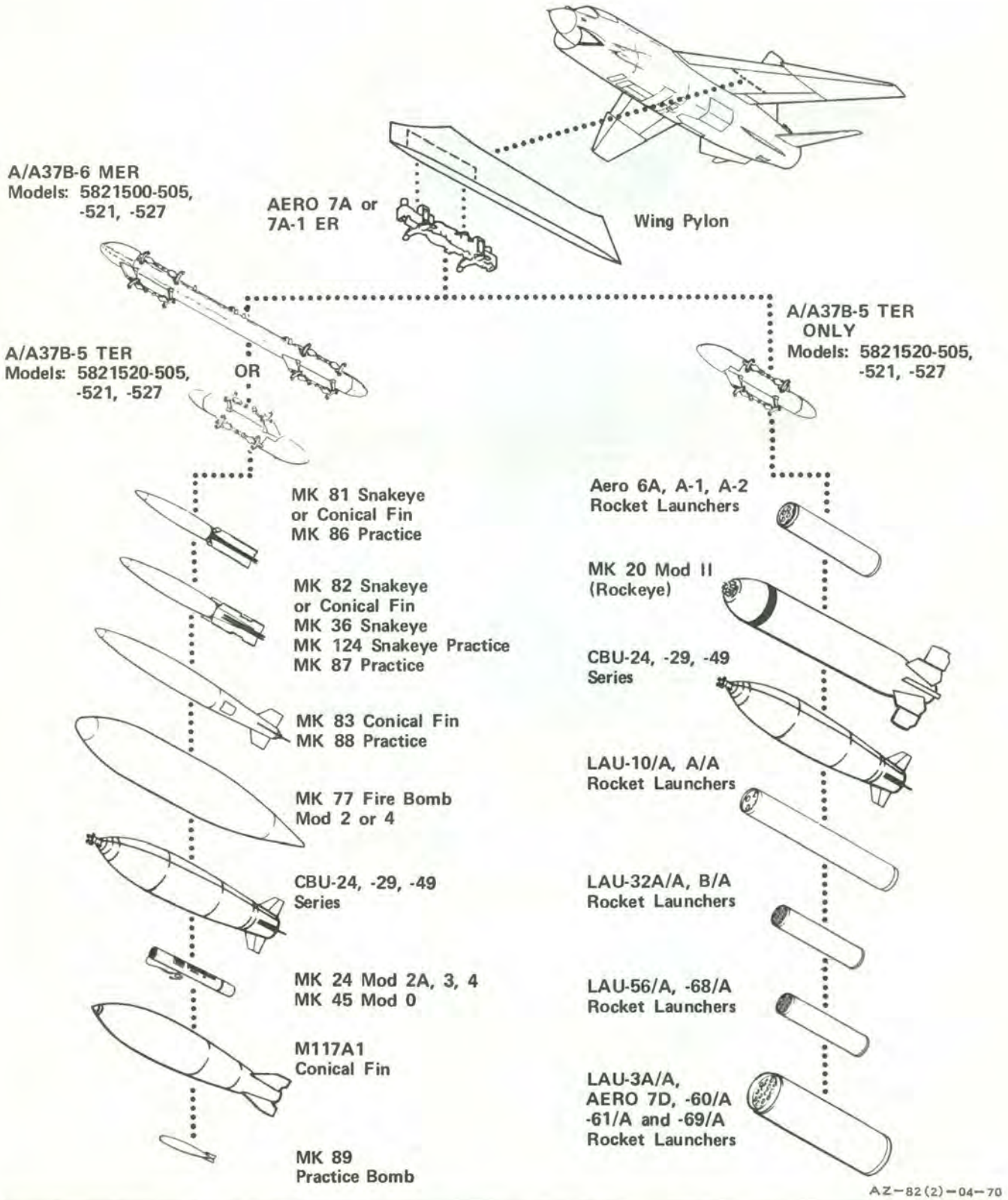
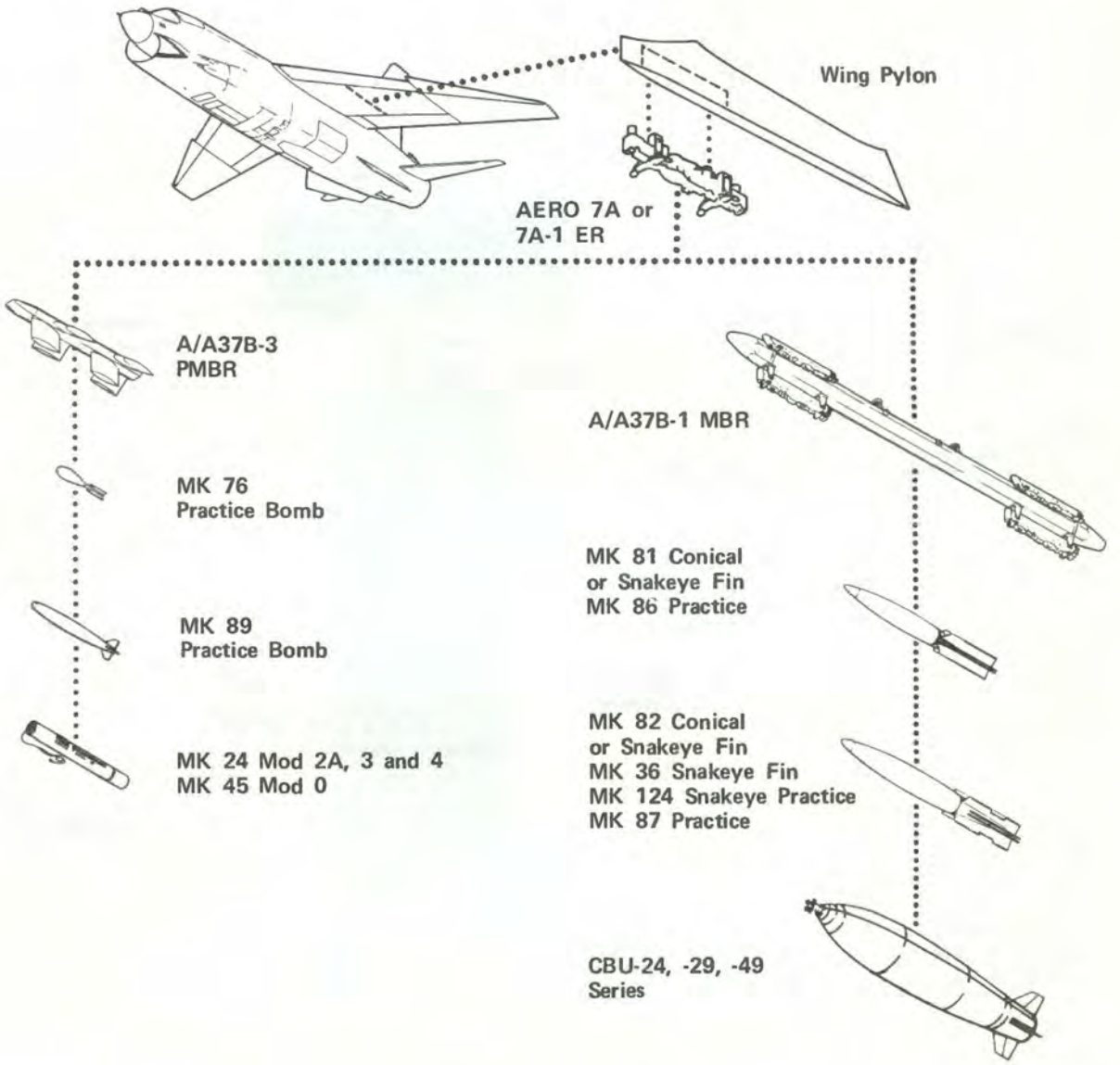


Figure 2-6 (U) (Sheet 2)

Pylons, Racks and Weapons Compatibility



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Figure 2-6 (U) (Sheet 3)

Pylons, Racks and Weapons Compatibility

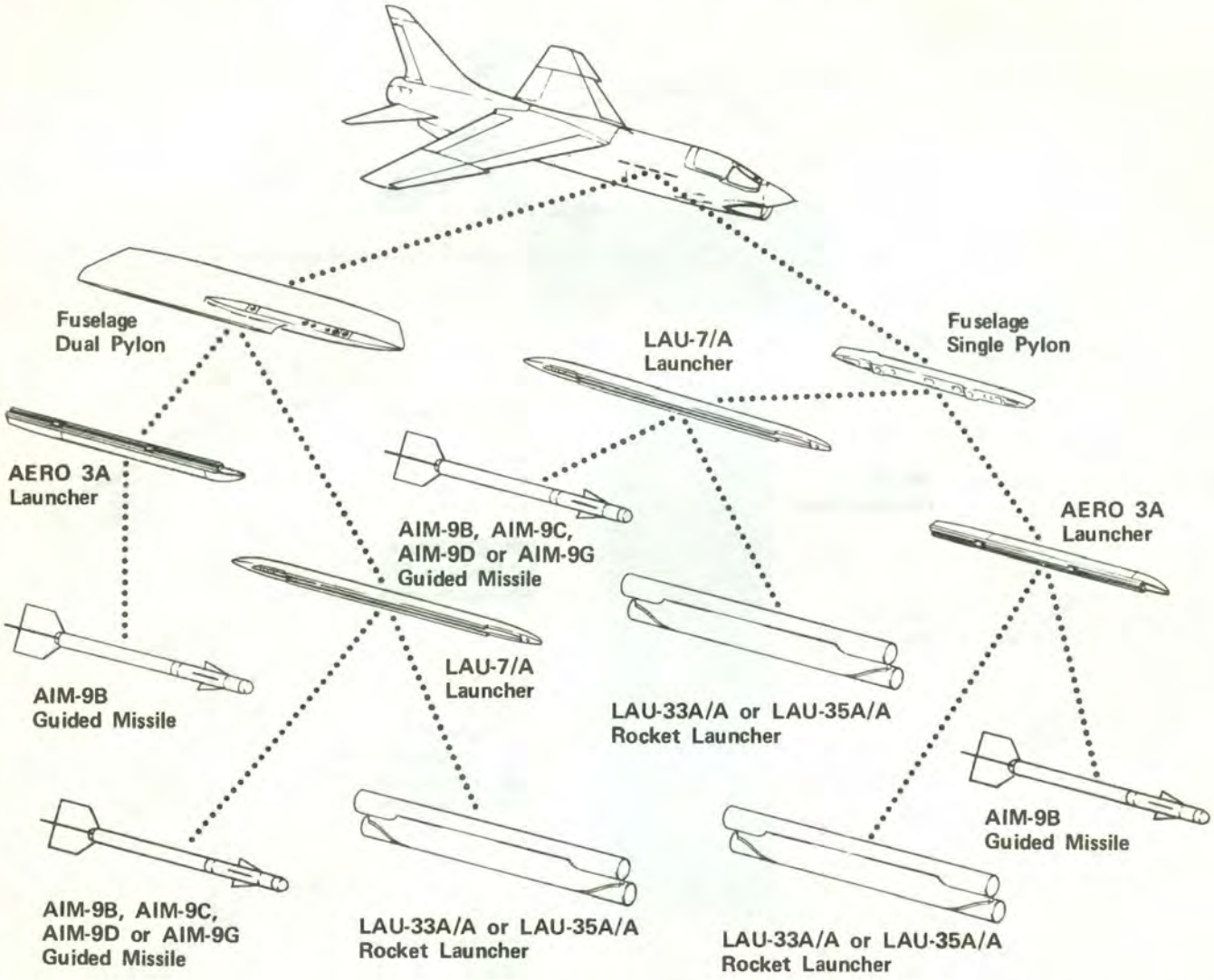


Figure 2–6 (U) (Sheet 4)

BOMB FUZING

INTRODUCTION

Proper selection of bomb fuzes is absolutely essential for safety of the delivery aircraft and effectiveness of the mission. Because mission requirements vary widely, it is necessary to maintain a number of different types of fuzes in stockpile, each fuze having its own unique delivery characteristics and imposing its own delivery requirements.

Fuzes may be most conveniently divided into two categories: electrical or mechanical. Each category has its own advantages and disadvantages. The primary advantage of electric fuzes is flexibility. They allow the use of advanced VT devices for airbursts, they can provide inflight selection of arming and functioning delay times, and they impose no speed restrictions.Electric fuzes, however, are more prone to early burst or arming, are more susceptible to electromagnetic radiation. (HERO), and increase the opportunity for pilot error in the selection of fuzing options. Mechanical fuzes are more reliable in operation but generally no inflight options of arming and functioning delays are available. The arming vanes and arming wires used with mechanical fuzes impose carriage and release restrictions.

Pertinent characteristics of these types of fuzes are summarized below. A compatibility summary of authorized bomb/fuze combinations and detailed summary sheets for each fuze currently authorized for carriage are provided in this section.

MECHANICAL FUZES

Most current mechanical fuzes contain the same basic elements and operate on a similar principle. See figure 2–7.

Fuze Arming

An arming vane on the fuze is driven by the air stream and provides mechanical energy to operate the fuze mechanism. This vane is held stationary while on the aircraft by an arming wire, which extends through the blades of the vane and is connected to an arming solenoid on the bomb rack.

If the weapon is to be released armed, the bomb rack solenoid is energized, thus locking the arming wire to the rack. Upon bomb release, the arming wire is withdrawn from the fuze and the arming vane begins rotation.

This rotation drives a gear train in the fuze which removes safety blocks and aligns the firing pin with a sensitive explosive detonator. The fuze is then considered armed and ready to function.

The gear train mechanism is designed to provide a definite delay after separation from the aircraft. This is called "arming delay."

Some of the latest fuzes permit the selection of various arming delays before flight and also contain a governor mechanism so that arming delay time will remain constant regardless of the release airspeed.

Fuze Functioning

With most impact fuzes, the firing pin is driven into a detonator or primer on impact. This, in turn, initiates an explosive booster and detonates the main charge in the weapon.

In air burst (time) fuzes, the firing pin is actuated by a preset clockwork mechanism rather than by impact.

A short delay (functioning delay) between impact and detonation can be provided by the use of slow-burning pyrotechnic elements. The delay element is integral to some fuzes and in others must be inserted in the fuze before installation in the bomb. For long delays (several seconds up to several hours) various methods are used including pyrotechnic, clockwork, or electric delay elements.

Selection of the proper functioning delay is necessary to maximize the effect of the bomb against various targets. The Joint Munitions Effectiveness Manual (JMEM) provides data on this subject.

Safe-Jettison

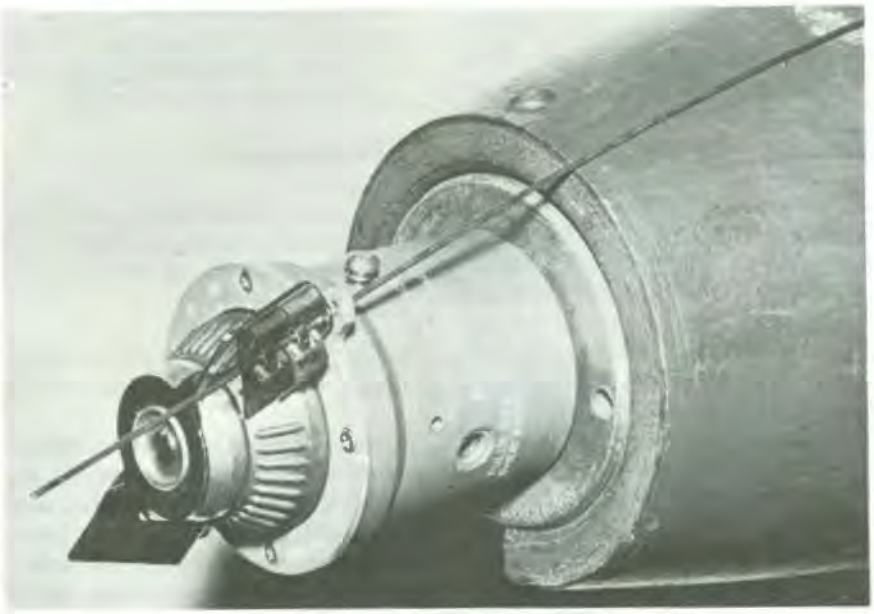
To safe-jettison a mechanical fuze, the bomb rack solenoid is deenergized allowing the arming wire to remain with the weapon on release. This locks the arming vane and prevents fuze arming.

In bomb racks used on jet aircraft, it has been necessary to increase the holding tension of the solenoid in the deenergized (SAFE) position. This prevents the high-speed airstream from inadvertently pulling the arming wire from the solenoid. Under service use environment, this holding tension can further increase to the point where it is impossible to jettison a weapon in the safe condition regardless of the position of the mechanical fuze arming switch. To minimize this possibility, maintenance and loading procedures outlined in current Technical Directives and Loading Manuals must be carefully observed.

If an unarmed weapon impacts with sufficient velocity on a hard surface, a significant detonation can still occur, with bomb fragmentation creating a hazard to the delivery aircraft. Therefore, if it is necessary to safe-jettison stores,

Mechanical Fuzes

M904E2/E3 NOSE FUZE



CHARACTERISTICS

Type . . . . . Mechanical-impact
Location . . . . . Nose
Limit speeds
Max carriage . . . . . 475 KIAS
Max release . . . . . 525 KIAS
Min release . . . . . 175 KIAS
Inflight options . . . . . None
Authorized bombs . . . . . M117, Mk 80 series LD, SNAKEYE I

ARMING AND FUNCTIONING DELAYS (Preflight Selectable)	
ARMING (Sec)	2/4/6/8/10/12/14/16/18
FUNCTIONING (Sec)	Instant/.01/.025/.05/0.10/0.25 *
Arming Tolerance: ±10% of arming delay setting	

DESCRIPTION

The M904E2/E3 fuzes permit preflight selection of several different arming and functioning delays. The arming delays are selected by a dial on the nose of the fuze. Functioning delays are selected by installation of the appropriate delay element in the fuze prior to installation in the bomb. The E3 embodies internal design changes which provide improved reliability against hard targets and increases sensitivity against soft targets (mud or water) in the retard mode. The E2 may dud if delivered against soft targets in the retard mode.

Due to the potential hazards of short arming delays, a stop screw in the head of the fuze must be removed to select the 2- or 4-second setting. The stop screw must not be reinstalled with the fuze set at 2 or 4 seconds or the fuze may dud.

The 2- and 4-second settings are for use in the retard mode. See table for minimum safe arming times. The fuze must be interconnected with the Snakeye fins by an arming wire if delivery is to be in the retard mode.

If this fuze is used with the M1A1 fuze extension (Daisycutter), a nondelay (INST) element must be installed in the fuze.

Regardless of the delay setting used, any mechanical nose fuze may detonate instantaneously on impact with very hard targets (concrete runways, dams) and is therefore ineffective when penetration is desired. Use tail fuzes for these conditions.

PREFLIGHT CHECKS

Assure that proper fuze is installed and desired arming delay set. Check arming wire rigging, Fahnestock clips, and removal of warning tags. Check that stop screw is removed at 2- and 4-second setting.

WARNING

If observation window shows full red at any setting, fuze is armed. The M904E2 will show a white line and the E3 will show a white S on a green background at the 6- and 18-second settings if fuze is fully safe. A white line or green background at any setting other than 6 or 18 indicates partial arming. Do not use a partially armed fuze; arming delays will be shorter than that set on the dial.

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Figure 2-7 (C) (Sheet 1)

Mechanical Fuzes

M1A1 FUZE EXTENSION (DAISYCUTTER)



CHARACTERISTICS

Type . . . . . Fuze Extension (Daisycutter)
Location . . . . . Nose
Limit Speeds:
Carriage and Release . . . . . 475 KIAS
Authorized Bombs . . . . . Mk 80 Series, M117A1
Authorized Fuzes M904E2/E3

DESCRIPTION

The M1A1 fuze extension is an explosive-filled metal tube which provides above ground burst capability. This capability improves the effectiveness against personnel and unarmored targets.

The fuze extension contains Composition B which is sealed in a tubular insert fitted loosely in the metal tube and is available in 18-inch and 36-inch lengths.

See External Stores Limitations Charts for minimum release intervals and restrictions on bomb rack loading.

WARNING

The M1A1 fuze extension is not authorized for carrier-based use and is restricted from any arrested landings.

If an unsuccessful attempt to release has been made during flight, weapons equipped with the fuze extension should be jettisoned prior to landing.

PREFLIGHT CHECKS

Make the normal checks prescribed for the fuze which is installed. Ensure that the fuze delay is set for INSTANTANEOUS functioning delay.

A single length of arming wire must be used. Arming wire extensions may break upon release and cause duds.

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Figure 2-7 (C) (Sheet 2)

Mechanical Fuzes

AN-M173A1/M918 MULTIPOSITION IMPACT FUZES



CHARACTERISTICS

Type ..... Mechanical-impact
Location ..... Nose, tail or side
Limit speeds
Max carriage ..... 475 KIAS
350 KIAS (see AN-M173 discussion)
Max delivery ..... 525 KIAS
450 KIAS (see AN-M173 discussion)
Min delivery ..... None
Inflight options ..... None
Authorized bombs
AN-M173A1 ..... Mk 77 Mod 2/4 and Mk 79
M918 ..... Mk 77 Mod 4

ARMING AND FUNCTIONING DELAYS	
ARMING (A Function of Airspeed)	FUNCTIONING
0.8 seconds at 350 KIAS	AN-M173A1 – Instantaneous
0.6 seconds at 500 KIAS	Instantaneous M918 – 0.3 seconds

DESCRIPTION

The AN-M173A1 and M918 fuzes were designed for use in firebombs and are similar except that the M918 has been altered to provide a 0.3-second functioning delay. Although these fuzes are physically interchangeable, they must be installed only in the specific igniters indicated below to ensure proper functioning.

To increase reliability, two fuzes are normally installed in all firebombs and both fuzes must be of the same type. The 0.3-second delay provided by the M918 will produce a larger ground pattern with longer burn time than that resulting from instantaneous fuzing. The fireball at impact may, however, appear smaller to the pilot. Use M918 in preference to the AN/M173A1.

The AN-M173AI fuze (with AN-M23A1 igniter) is compatible only with the nose and tail wells of the Mk 77 Mod 2/4 and two side wells of the Mk 79. At high speeds, vibration can develop in the tail section of the Mk 77 of sufficient magnitude to sever the arming wire and arm the fuze. As a result, the lower speed restrictions noted earlier must be observed when this fuze is installed in the tail well of the Mk 77 Mod 2/4.

The M918 fuze (with Mk 273 Mod 0 igniter) is compatible only with the two side wells of the Mk 77 Mod 4. It may be carried and delivered at the high speeds noted above.

PREFLIGHT CHECKS

Ensure that the proper fuze and igniter combination is installed. Check arming wire rigging, Fahnestock clips, fuze condition, and removal of fuze warning tags.

WARNING

SAFE jettison of fire bombs with these fuzes installed cannot be assured. Impact may rupture the igniter, regardless of ARM/SAFE condition of the fuze, and ignite the fuel mixture.

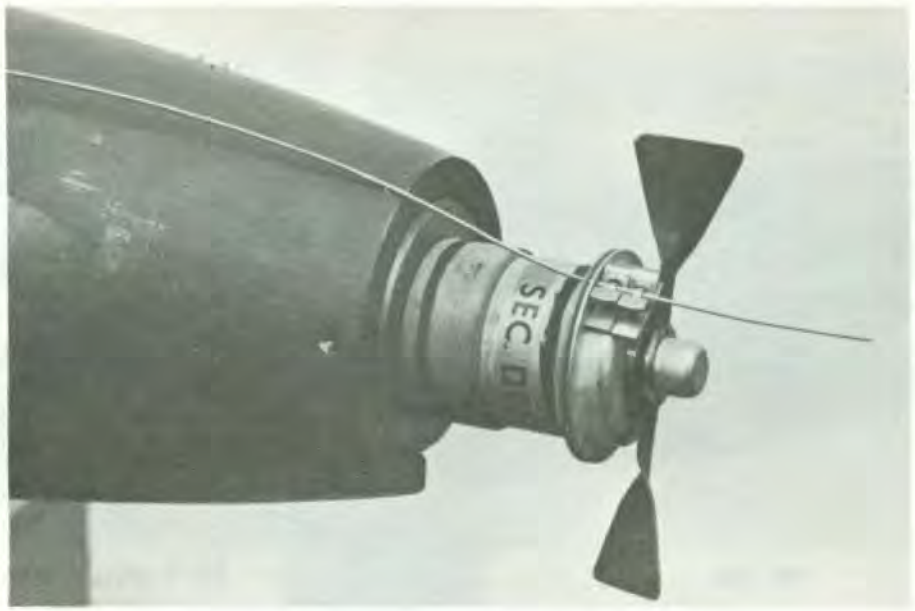
These fuzes should be considered armed if the clearance between the hub of the arming vane and the hexagonal shoulder of the fuze body is greater than 3/16 inch.

AZ-304(2)-03-70

Figure 2-7 (C) (Sheet 3)

Mechanical Fuzes

MK 347 NOSE FUZE



CHARACTERISTICS

Type . . . . . Mechanical-impact
Location . . . . . Nose
Limit speeds
  Max carriage . . . . . 475 KIAS
  Max release . . . . . 400 KIAS
  Min release . . . . . 175 KIAS
Inflight options . . . . . None
Authorized bombs
  Mk 347 . . . . . Mk 81/82 LD and SNAKEYE

ARMING AND FUNCTIONING DELAYS	
ARMING	.7 to 1.2 Seconds (a function of airspeed)
FUNCTIONING	12 Sec

DESCRIPTION

The sensitivity of the Mk 347 will provide detonation on impact with shallow water or marsh. This sensitivity and the long functioning delay were designed for slow-speed, low-altitude retarded delivery. Release of this fuze at speeds in excess of 400 KIAS will result in unpredictable operation due to aerodynamic instability. Use only the FLAT vane that is shipped with these fuzes.

Although the probability of early burst is low, the short arming time of the Mk 347 does not provide safe separation in the event an early burst does occur. This fuze should not be used if M904E3 fuzes with selectable arming times are available. The fuze must be interconnected with the Snakeye fin by an arming wire if delivery is to be in the retarded mode.

This fuze must not be used with the M1A1 fuze extension (Daisycutter) due to the long functioning delay.

Regardless of the delay settings used, any mechanical nose fuze may detonate instantaneously on impact with very hard targets (concrete runways, dams) and are therefore ineffective when penetration is necessary. Use tail fuzes for these conditions.

WARNING

This fuze does not provide safe separation in the event of early burst. Use release conditions in which there is a low probability of bomb-to-bomb collision.

PREFLIGHT CHECKS

WARNING

Fuze should be considered armed if the clearance between the two flanges on the head of the fuze is greater than 1/8 inch.

Check arming wire rigging, Fahnestock clips, removal of warning tags, and fuze condition. A decal which reads '12 SEC DELAY' is affixed to the fuze body. Fuze should be considered armed if the clearance between the two flanges on the head of the fuze is greater than 1/8 inch.

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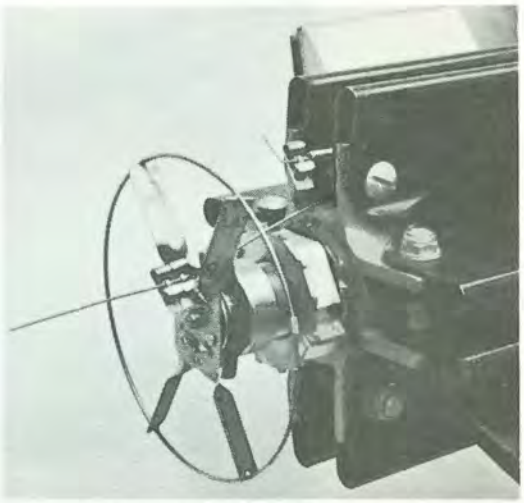
Figure 2-7 (C) (Sheet 4)

Mechanical Fuzes

MK 346 LONG DELAY FUZE



MK 346



MK 4 MOD 1 TAIL DRIVE

CHARACTERISTICS

Type . . . . . Mechanical long delay
Location . . . . . Tail

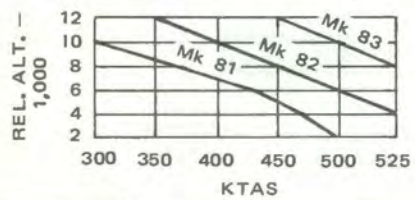
Carriage Restrictions: These restrictions are imposed due to tail fin vibrations which can cause damage to fuze and arming vane.

Snakeye fins . . . . . 525 KIAS
Conical fins . . . . . 450 KIAS

Authorized bombs . . . . . Mk 81, 82, 83 LD and SNAKEYE I

DELIVERY RESTRICTIONS

The following delivery parameters will ensure 90% fuze reliability. These restrictions may be exceeded for tactical reasons but reliability will be degraded. See DESCRIPTION for further details.

LAND TARGETS		WATER TARGETS
UNRETARDED	RETARDED	UNRETARDED ONLY
MAX RELEASE SPEED  MIN REL SPEED – No MINIMUM MIN REL ALT – 1,000 ft. AGL	MAX REL SPEED – 525 KTAS MIN REL SPEED – 300 KTAS MIN REL ALTITUDE – 300 ft. AGL	MAX REL SPEED – 525 KTAS MIN REL SPEED – 450 KTAS MIN REL ALTITUDE – 3,000 ft AGL

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Figure 2–7 (C) (Sheet 5)

Mechanical Fuzes

MK 346 LONG DELAY FUZE

DESCRIPTION

Mk 346 is a clockwork fuze which provides increased safety as compared with the older chemical delay fuzes. The fuze employs two-stage arming; air travel plus impact are necessary to complete arming. The functioning delay does not commence until impact.

The Mk 346 is sensitive to impact angle and velocity. Impact at high speeds on hard targets can damage the timer. As bomb size increases, higher impact velocities can be tolerated. Impact angles of less than 15° on any type of target or low impact velocities on water targets will fail to arm the fuze. The delivery restrictions outlined in the preceding table will ensure 90% fuze operability. For absolute maximum operability, delivery in the retarded mode is recommended. Failure to observe the Mk 81/82 restrictions can reduce fuze reliability to about 60%.

The fuze contains an anti-removal device which deters removal of the fuze from the bomb after it has armed. The delay setting dial cannot be observed once the fuze has been installed in the bomb.

A Mk 3, 4, or 5 arming assembly is used to provide arming action to the fuze. These assemblies consist of an arming vane, a drive mechanism, and a drive shaft and may be used with either conical or Snakeye fins. The Mod 0 and Mod 1 arming assemblies are speed governed; the Mod 2 is direct drive. This accounts for the variation in arming times as shown above.

PREFLIGHT CHECKS

Fuze will be difficult to observe. Check arming wire rigging, condition of arming vane, and removal of warning tags. The Mod 2 arming assembly has DIRECT DRIVE stencilled on the hub of the fuze drive. A steel nose plug should be installed in the nose of the bomb to lessen the probability of weapon breakup on impact.

WARNING

A red and black band in the observation window indicates that first stage arming has occurred. Timer may be running.

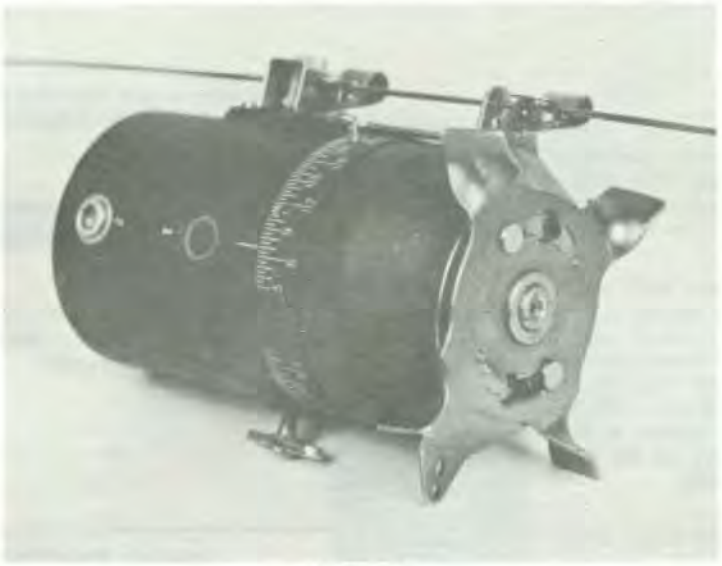
ARMING AND FUNCTIONING DELAYS	
ARMING	With Governed Arming Assembly (Mod 0/1) 1.5 to 2.0 seconds (unretarded) plus impact 1.5 to 4.0 seconds (retarded) plus impact **NOTE** At high speed release, retardation causes fuze drive to lose speed thus increasing the arming time. – With Direct Drive Arming Assembly (Mod 2) Less than 1 second plus impact
FUNCTIONING (Preflight Selected)	30 minutes to 33 hours (15 min increments)

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Figure 2–7 (C) (Sheet 6)

Mechanical Fuzes

M907E1/E2 TIME FUZE



M907E2

CHARACTERISTICS

Type . . . . . Mechanical time (airburst)
Location . . . . . Nose
Limit speeds
Max carriage . . . . . 600 KIAS CBU-24/29/49
Max release . . . . . 600 KIAS CBU-24/29/49
Min release . . . . . 175 KIAS
Inflight options . . . . . None
Authorized bombs . . . . . CBU-24/29/49-1B, -1B Mod, -A/B, -C/B

ARMING AND FUNCTIONING DELAYS	
ARMING	Arming delay is 40% to 60% of the functioning delay.
FUNCTIONING	Preflight selected M907E1 – 4 to 92 seconds M907E2 – 3 to 92 seconds

DESCRIPTION

M907E1/E2 series fuzes provide an airburst capability for dispenser or cannister type weapons. Functioning accuracy is ±1 second at settings below 45 seconds and ±1.5 seconds at all settings above 45 seconds. Both the arming and functioning delay times begin simultaneously upon release.

M907 fuzes will not arm reliably at speeds less than 175 KIAS. If released in loft delivery, the trajectory airspeed of the bomb must not fall below 175 knots during the arming portion of travel or a dud will result.

PREFLIGHT CHECKS

Assure that the proper delay is set and lock screw is tight. Check arming wire rigging, Fahnestock clips, removal of fuze warning tags, and fuze condition. Ensure that arming vane is securely attached.

WARNING

An apperture in the body of the fuze (marked with the numeral 2) is covered with an aluminum foil seal. If brass plunger (slider assembly) protrudes through the foil the fuze is armed. Foil may be missing, but as long as slider assembly does not protrude from fuze body the fuze is safe.

Fuze does not require impact for detonation and must not be used in any HE bomb.

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Figure 2-7 (C) (Sheet 7)

Mechanical Fuzes

MK 339 MOD 0 TIME FUZE



CHARACTERISTICS

Type . . . . . Mechanical time (Airburst)
Location . . . . . Nose
Limit speeds
Max carriage . . . . . No fuze imposed limitations
Max delivery . . . . . No fuze imposed limitations
Min delivery . . . . . 225 KIAS
Inflight options . . . . . None
Authorized Bombs . . . . . Mk 20 Mod 0 (Rockeye II), CBU 24/B

ARMING AND FUNCTIONING DELAYS	
Arming – 1.1 seconds	
Functioning – 1.2 to 50 seconds (0.1 sec increments) Preflight selected	
FUNCTION DELAY TOLERANCE	±0.1 second for settings from 1.2 to 10 seconds 1% of all settings over 10 seconds.

DESCRIPTION

The Mk 339 is a mechanical time fuze designed to provide an airburst capability for cluster and cannister weapons. It is currently authorized for use only with Rockeye II. The fuze has provisions for preflight setting of a primary and an option function delay. Either of these functioning delays may be set from 1.2 to 50 seconds. However, when installed in Rockeye II only the option time setting can be used and currently approved tactics dictate the use of only a 4.0- or 1.2-second functioning delay.

Rockeye II is shipped in an all-up condition with a Mk 339 fuze installed and with a primary wire and safety wire with a warning tag installed. The option arming wire is removed at the depot thereby preselecting the option delay setting. The fuze is shipped with the option delay set at 4 seconds and the primary set at 0. The option delay may be reset to 1.2 second if required by tactical conditions. Settings are made on 2 dials which appear in a window in the side of the fuze. Primary dial is black; option dial is silver. The dials will not be visible when installed in ROCKEYE.

At release, withdrawal of the primary arming wire unlocks the arming vane, starts the timer and selects the option delay. The arming and functioning delays commence simultaneously at release The timer functions with an accuracy of plus or minus 1/2%.

WARNING

Fuze does not require impact to function and should not be used in any HE bomb.

PREFLIGHT CHECKS

WARNING

If red-tipped plunger protrudes into plastic bubble on side of fuze, the fuze is armed and should be considered dangerous. This bubble is visible through an observation window in Rockeye nose fairing.

Only the arming vane will be clearly visible. Check rigging of primary arming wire and removal of safety tag. No Fahnestock clips are used and arming wire should extend only 1/2 inch beyond arming vane clamp.

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Figure 2-7 (C) (Sheet 8)

release bombs over water or soft ground, at low airspeeds, and above the fragmentation envelope. These precautions are particularly applicable to noze fuzes due to their exposed locations. Bombs may detonate on hard targets even without a fuze installed.

Shear Safe

In most modern fuzes, the firing pin and the detonator or primer are not aligned until the fuze arms. Should an unarmed fuze shear off the bomb on impact, the weapon will remain relatively safe. This provision greatly reduces the probability of bomb detonation in the event of a landing accident.

ELECTRIC FUZES

Basic Theory of Operation

There are two basic types of electric fuzes. These are:

DC-only Preselected fuzes – M990E-1, -3 and -4

DC-only Retard Sensing fuzes – Mk 344 and Mk 376

The Mk 344/376 fuzes are being produced as eventual replacements for the M990 series.

While there are important differences between these fuzes which pilots must understand, the basic operating principles are similar. See figure 2–8.

Electric fuzes receive their operating energy from the delivery aircraft via the Fuze Function Control Set (AWW-2A), a bomb-rack cable assembly, and a cable network in the weapon. This energy is applied to the fuze during the first few inches of bomb travel after release from the bomb rack.

For each arming/functioning delay combination provided by the fuze, there will be a discrete electrical circuit or channel in the fuze. Each of these channels is designed to provide a specific electrical delay when a voltage is applied.

Preselected DC-Only Fuzes (M990 E1, E3, E4)

These are basic +300-volt dc fuzes in which a single arming/functioning delay circuit has been preselected before issue. These fuzes need only dc voltage for their operation and no delay options are available to the pilot. Inadvertent application by the pilot of an additional rf signal can cause unreliable operation and possibly dangerous arming delays.

DC-Only Retard Sensing Fuzes (Mk 344 – Mk 376)

These fuzes use a deceleration sensing device to automatically select the proper arming delay circuit for either retarded or unretarded delivery. Four different dc voltage/polarity combinations are used to provide an in-flight option of several functioning delays. Inadvertent application of RF signals to these fuzes can cause erratic arming delays.

Electric Fuze Operation

Regardless of the method used to select the delay, at completion of the required arming time the dc voltage causes rotation of a mechanical rotor in the fuze. This rotor aligns the detonator with the booster and closes all the firing circuits with the exception of the final inertia-operated impact switch. At this point, the fuze is armed and is in all respects ready to fire.

On impact, the impact switch closes and the stored dc voltage detonates the fuze after the selected functioning delay has elapsed.

Mechanical safety is provided in electric fuzes by a "gag rod" which physically prevents rotation of the rotor. This gag rod is held in place by an arming wire which is withdrawn from the fuze at weapon release. For electric fuzes, arming wire is positively connected to the bomb rack rather than to one of the bomb arming solenoids. As a result, the gag rod is always withdrawn when the weapon leaves the rack regardless of the position of the mechanical fuze arming switch in the cockpit. Thus, to assure safe jettison, the Fuze Function Control Set must be in the SAFE position to prevent any electrical energy from entering the fuze. The impact switch in electric fuzes is sensitive to shock in any direction, and not merely along the longitudinal axis of the bomb. Therefore, the probability of an early burst due to bomb-to-bomb collision after fuze arming is greater than with mechanical fuzes which require a longitudinal force.

VT Elements

VT sensing elements (figure 2–9) may be used in conjunction with electric fuzes to provide an airburst capability. With these devices, the electric fuze operates in a normal manner except that an independent source of electrical energy from the VT device bypasses the impact switch in the electric fuze and detonates the weapon at a desired burst height. In this application, the electric fuze will detonate on impact in the event the VT element has not operated. When VT elements are being used, it is suggested that the electric fuze be set for instantaneous functioning delay in order to provide the most effective backup in case of VT element failure.

Electrical Fuzes

MK 344/376 TAIL FUZE



MK 344 FUZE

CHARACTERISTICS

Type . . . . . Electric-impact
Location . . . . . Tail
Limit Speeds
Max release . . . . . No fuze imposed limitations
Min release . . . . . 400 KIAS (retarded mode only)
Inflight options . . . . . 3 functioning delays plus airburst if used with VT element. Indirect control of arming (See discussion.)

Authorized bombs . . . . . Mk 80 series, Snakeye I, and M117
Control system AWW-2A

ARMING AND FUNCTIONING DELAYS			
ARMING	Automatically selected by the fuze depending upon delivery mode.		
		Mk 344	Mk 376
	Retarded	2.6 sec	2.6 sec
	Unretarded	5.5 sec	10.0 sec
FUNCTIONING	Cockpit selectable – 0/.015/.1 sec (plus VT option)		
Arming delay tolerance		–10 to +20%	

DESCRIPTION

The Mk 344 and Mk 376 fuzes are identical in all details except for the difference in arming delay times in the unretarded delivery mode. The longer arming delay (10 seconds) provided by the Mk 376 permits use of this fuze in straight and level, unretarded delivery. This mode is not authorized with the Mk 344 for safe separation reasons.

Mk 344/376 fuzes are designed as replacements for the M990 series and provide improved safety and reliability. They are initiated by dc voltages and can be controlled by the electric fuzing system (AWW-2A). Arming delays are not directly selectable by the pilot; however, a timer/decelerometer (Mk 31) integral to the fuze automatically selects a 2.6-second arming delay upon sensing weapon retardation. If retardation does not occur, the Mk 344 automatically selects a 5.5-second delay, the Mk 376 a 10-second delay. The pilot has the option of three functioning delays. Refer to table for AWW-2A cockpit settings.

The Mk 344/376 can be used in combination with the M20 or Mk 43 VT elements to provide a capability for VT initiation coupled with any one of the three delays. This mode is particularly useful for jungle penetration wherein the fuze will be initiated by VT sensing of the tree tops, but will delay detonation until bomb has penetrated the foliage. (See M20/Mk 43 illustrations for further details.)

The 400 KIAS minimum speed restriction is due to the fact that the Mk 31 decelerometer will not sense sufficient retardation at lower speeds. This could result in the selection of the longer delay and a dud. This fuze must be used with ejector racks only.

WARNING

If the arming wire is inadvertently withdrawn from the Mk 344/376 fuze prior to weapon release, the sensing device will not operate and the fuze will arm at 2.6 seconds after release, regardless of delivery mode.

A special circuit is included in these fuzes to prevent the potentially dangerous situation in which the bomb fails to retard, ricochets, and then detonates on subsequent impact. The "dudding circuit" will dud the bomb on initial impact provided impact occurs between 2.5 and 5.5 seconds (10 seconds for Mk 376) after release and the Snakeye fins have not operated. See Minimum Safe Arming Times and Speeds table.

WARNING

Do not make level release of the Mk 344 at altitudes above 400 feet AGL. If the Snakeye fins malfunction, time of fall will be sufficient to permit 5.5-second arming and aircraft may be within fragmentation envelope. The Mk 376 is the preferred fuze for all level releases, either retarded or unretarded.

PREFLIGHT CHECKS

The installed fuze is difficult to observe. Identifying decals are provided with each fuze to be affixed to the after bomb body as fuze is installed. Assure that electric fuzing cable is connected and arming wire is rigged as prescribed in Airborne Weapon/Store Loading Manual.

AWW-2A SETTINGS

MK 344/376 MOD 0 FUZES (DC only retard sensing)

FUNCTION KNOB	ARMING DELAY	FIRING DELAY	INTERLOCK OVERRIDE
Set to desired voltage/ polarity: +300 – INST +195 – INST -300 – 0.1 -195 – 0.015	These three switches are inoperative with FUNCTION knob settings shown. Arming delays are automatically selected as follows: Retarded / Unretarded Mk-344 2.6 / 5.5 Mk-376 2.6 / 10.0		

CAUTION

Inadvertent application of an rf signal may cause unreliable or erratic arming delays.

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Figure 2-8 (C) (Sheet 1)

Electrical Fuzes

M990E-1/E-3/E-4 TAIL FUZE



CHARACTERISTICS

Type . . . . . Electric-impact
Location . . . . . Tail
Limit speeds . . . . . No fuze imposed restrictions
Inflight options . . . . . None
Authorized bombs . . . . . All Mk 80 series (LD only), M117
Control system AWW-2A

ARMING AND FUNCTIONING DELAYS			
	E1	E3	E4
ARMING	5.5	10	5.5
FUNCTION	.050	0	0
Arming Tolerance	−10 to +20%		

AWW-2A/2B OPTION SELECTOR SETTINGS			
FUNCTION KNOB	ARMING DELAY KNOB	FIRING DELAY KNOB	INTERLOCK OVERRIDE SWITCH
1. Set to position +300 only.	1. These 3 knobs are inoperative with FUNCTION knob setting shown in column 1. 2. Arming and functioning delays are preselected. See specific fuze for available delays.		

CAUTION

The application of an improper dc voltage or of an rf signal to a dc only fuze can cause unreliable or erratic arming delays.

DESCRIPTION

The M990E-1/E-3/E-4 are electric tail fuzes for use in unretarded Mk 80 series and M117 bombs. These fuzes operate on dc voltage only and provide no inflight options of arming or functioning delays. The 5.5-second arming time provided by the E-1 and E-4 is for use in dive delivery; the 10-second delay of the E3 is for level delivery.

About one out of 1,000 M990E series fuzes will detonate immediately upon arming. This increases to 4 out of 100 when used with VT sensing elements. This condition and the increased hazards of bomb-to-bomb collisions at high speed release demand extreme care in selection of arming times. For minimum safe arming times, refer to illustration of Minimum Safe Arming Times and Speeds.

Refer to table for cockpit settings on AWW-2A fuze function control set.

WARNING

Electric fuzes are particularly susceptible to early bursts due to bomb-to-bomb collision. When using 5.5-second arming time, employ appropriate postrelease maneuvers for maximum bomb/aircraft separation.

Use of M990 series fuzes is not authorized in the retarded mode.

CAUTION

Use caution in selecting fuze option settings with the AWW-2A fuze function control set. The application of an rf signal or a dc voltage other than +300 volts to any M990 series fuze can cause unreliable or erratic arming delays.

PREFLIGHT CHECKS

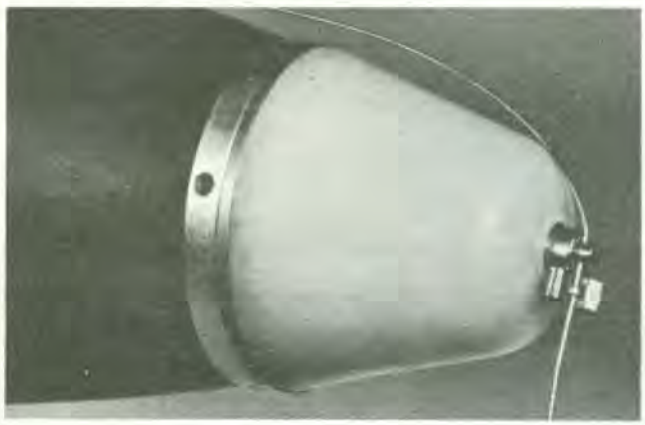
Identifying decals are provided with each fuze to be affixed to the bomb body as the fuze is installed. Assure that electric fuzing cable between rack and the bomb is connected and arming wire is rigged as prescribed in Airborne Weapons/Stores Loading Manual.

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Figure 2-8 (C) (Sheet 2)

Sensing Elements

M20/20A1 SENSING ELEMENT



CHARACTERISTICS

Type	VT sensing element
Location	Nose
Color/markings	M20 Tan, M20A1 Dark red
Inflight options (See table.)	With M990 series fuzes: VT (INST) or non-VT With Mk 344/376 fuzes: VT (INST), VT with delay, or non-VT
Impact angle	45° or greater. Burst height decreases as angle decreases
Burst height:	
High setting	100 to 160 feet
Low setting	20 to 60 feet
Max carriage and release speeds	No M20/20A1 imposed limitations
Min release altitude	2,000 ft AGL
Authorized bombs	Mk 80 LD series and M117

DESCRIPTION

The M20/20A1 is a proximity sensing device which provides an airburst capability for electrically fuzed nonretarded bombs. It employs a forward-looking sensing lobe designed for the steep-angle/high speed impacts common to free-fall weapons. If used with retarded weapons or released below 2,000 feet AGL, a surface burst may result. The M20 and M20A1 are functionally identical.

Electrical energy for operating the sensing element is provided by a battery integral to the M20/20A1. This battery is mechanically initiated by the withdrawal of the arming wire from the nose of the M20 at weapon release. The battery can also be initiated electrically (with the arming wire still in place) by application of an rf energy signal. However, the use of rf signals with any of the current electric tail fuzes is not authorized and, as a result, the M20/20A1 must always be initiated mechanically when VT operation is desired.

WARNING

Use care in selecting fuze option with the fuze function control set (AWW-2A). If the weapon is dropped with the M20 arming wire in place for intended non-VT operation, the VT sensing element can be electrically initiated by the inadvertent application of an rf signal. Under such a condition, the sensing signal can be reflected by the arming wire and cause the bomb to detonate at arming.

The M20 contains no explosive elements. Its only function is to provide an electric firing signal to the electric tail fuze. It cannot detonate the bomb until completion of the arming delay of the particular tail fuze which is installed.

In the event that the M20 fails to operate, the tail fuze will serve as a backup on impact. For most effective backup operation it is recommended that the tail fuze be set for INST functioning.

Release altitude must be sufficient for tail fuze to arm at least 50 feet above desired burst height setting. Do not use M20 in retarded mode.

WARNING

For normal delivery, do not release unretarded bombs closer than 200 milliseconds from the same rack or 100 milliseconds from different racks with M20 activated. Mutual interference between VT elements in bombs in close proximity can cause early bursts.

Observe minimum fuze arming times shown in Minimum Safe Arming Times and Speeds illustration.

PREFLIGHT CHECKS

Ensure that proper VT element is installed and all warning tags removed. Check that an arming wire is rigged in the nose and only one Fahnestock clip is attached.

Check for desired setting of the HI-LO switch.

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Figure 2-9 (C) (Sheet 1)

AWW-2A SETTINGS

M990 PRESELECT FUZES (DC ONLY); M990 E-1, E-3, AND E-4			
FUNCTION KNOB	ARMING DELAY KNOB	FIRING DELAY KNOB	INTERLOCK OVERRIDE SWITCH
Set to +300 only M20 must be mechanically initiated to obtain VT mode.	These three switches are inoperative with FUNCTION knob setting shown. Arming and functioning delays are preselected as follows: Fuze — Arming Delay — Functioning Delay (Backup Only) M990 E-1 — 5.5 — 0.050 E-3 — 10.0 — 0.000 E-4 — 5.5 — 0.000		

MK 344/376 FUZES			
FUNCTION KNOB	ARMING DELAY KNOB	FIRING DELAY KNOB	INTERLOCK OVERRIDE SWITCH
M20 must be mechanically initiated to obtain VT option. When so initiated, weapon will function in VT mode with delay indicated below. Set FUNCTION knob to desired voltage/polarity: +300 INST +195 INST -300 0.1 -195 0.015	These three knobs are inoperative with FUNCTION knob settings shown. Arming delays are automatically selected as follows: Retarded — Unretarded Mk 344 — 2.6 — 5.5 Mk 376 — 2.6 — 10.0		

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Figure 2-9 (U) (Sheet 2)

Sensing Elements

MK 43 TARGET DETECTING DEVICE (VT ELEMENT)



CHARACTERISTICS

Type	VT sensing element
Location	Nose
Color/markings	Dark green
Inflight options (See table.)	
With Mk 344/376 fuze	VT (INST), VT with delay, or non-VT
With M990 series fuze	VT (INST)
Impact angle	0° to 90° (optimum between 10° and 60°)
Burst height	16 feet (nominal). Decreases slightly as impact angle increases.
Limit speeds	No Mk 43 imposed limitations
Authorized bombs	Mk 80 LD series, SNAKEYE I and M117

DESCRIPTION

The Mk 43 is a proximity sensing device which provides an airburst capability for electrically fuzed bombs. It employs a side-looking sensing lobe designed primarily for the shallow angle/low speed impacts common to retarded weapons. It can be used with low drag weapons but burst heights will be slightly lower than nominal.

Mk 43 can be initiated either mechanically by withdrawal of the arming wire, or electrically by application of +300 volts. (See table.) The arming wire is an alternate means of initiation and is not a safing device. The Mk 43 can be electrically initiated with the arming wire in place.

WARNING

On all releases in which the VT element is to be actuated either mechanically or electrically, the arming wire (if one is rigged) must be withdrawn from the Mk 43 for safety reasons. If the arming wire is dropped with a weapon in which the VT element has been electrically actuated, the sensing signal can be reflected by the arming wire and detonate the bomb at fuze arming.

The Mk 43 contains no explosive components. Its only function is to provide an electric firing signal to the electric tail fuze. It cannot detonate the weapon until completion of the arming delay of the particular tail fuze which is installed.

When the Mk 43 is used with an M990 series electric tail fuze, *an arming wire is neither required nor should be rigged to the Mk 43.* The M990 requires +300 volts for operation and this voltage will also actuate the Mk 43. As a result, a non-VT option is not available with the Mk 43/M990 combination.

When the Mk 43 is used with the Mk 344/376 fuze, options of non-VT, VT with delay, and VT (INST) are available. Only the VT with delay option requires that an arming wire be rigged to the Mk 43. (See Mk 344/376 fuze.) For all other options, *an arming wire is neither required nor should be rigged to the Mk 43.* (See WARNING.)

In the event the Mk 43 fails to operate, the tail fuze will serve as a backup on impact. In such cases the selected functioning delay of the tail fuze will operate normally. For most effective backup operations, it is recommended that the tail fuze be set for INST functioning.

Release altitude must be sufficient for the tail fuze to arm at least 50 feet AGL.

WARNING

For normal delivery, do not release bombs from the same or different racks at closer than 60 milliseconds unretarded or 200 milliseconds retarded with Mk 43 activated. Mutual interference between VT elements in bombs in close proximity can cause early bursts.

Observe minimum fuze arming times listed in illustration of Minimum Safe Arming Times and Speeds.

PREFLIGHT CHECKS

Assure that the proper VT element is installed. Check that either an arming wire or a safety clip is rigged in the nose and all warning tags are removed.

When an arming wire is used, only one Fahnestock clip is attached.

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Figure 2-9 (C) (Sheet 3)

AWW-2A OPTION FOR SELECTOR SETTINGS

M990 PRESELECT FUZES (DC ONLY): M990E-1, E-3, AND E-4			
FUNCTION KNOB	ARMING DELAY KNOB	FIRING DELAY KNOB	INTERLOCK OVERRIDE SWITCH
Set to +300 only. Non-VT option not available with Mk 43/M990. +300 setting will initiate the Mk 43.	These three knobs are inoperative with FUNCTION knob setting shown in column 1. Arming and functioning delays are preselected as follows: Fuze — Arming Delay — Functioning Delay (Backup Only) M990E-1 — 5.5 — 0.50 E-3 — 10.0 — 0.00 E-4 — 5.5 — 0.00		

MK 344/376 FUZES (DC Only Retard Sensing)			
FUNCTION KNOB	ARMING DELAY KNOB	FIRING DELAY KNOB	INTERLOCK OVERRIDE SWITCH
Setting: Option: +300 VT/INST +195 NonVT/INST -300* VT/.1 delay -195* VT/.015 delay *With these two settings, Mk 43 must be mechanically initiated to obtain 'VT with delay' mode.	These three knobs are inoperative with FUNCTION knob settings shown in column 1. Arming delay is automatically selected as follows: Retarded — Unretarded Mk 344 — 2.6 — 5.5 Mk 376 — 2.6 — 10.0		

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Figure 2-9 (U) (Sheet 4)

Sensing Elements

DESTRUCTOR MK 36 (DST) ARMING AND FIRING SYSTEM



MK 30 ARMING DEVICE



MK 42 FIRING MECHANISM

CHARACTERISTICS

Type . . . . . Magnetic influence
Location . . . . . Nose and tail wells
Color/markings
Nose device . . . . . Green
Tail mechanism . . . . . Black with gold flange
Limit speeds
Max carriage . . . . . 475 KIAS
Max delivery . . . . . 525 KIAS (Retard mode only)
Min delivery . . . . . 175 KIAS
Inflight options . . . . . None
Authorized weapons . . . . . Mk 36 DST (Mk 82 Snakeye)

ARMING DELAYS (Preflight Selected)
Mk 30 Arming device 2/4/6/8/10/12/14/16/18 (Only 2-second setting authorized)
ARMING TOLERANCE 1.7 to 2.2 seconds at 2-second setting
Mk 42 Firing Mechanism Delays are of higher classification. See NAVORD OP 3529

DESCRIPTION

The Destructor Arming and Firing System (Modification Kit Mk 75) is designed to convert a Mk 82 Snakeye bomb to a Destructor which will provide a magnetic influence firing capability against shallow water or land targets. The system includes a mechanically operated Mk 30 arming device and a magnetic influence Mk 42 firing mechanism which are installed in the nose and tail wells respectively.

To prevent impact damage and excessive penetration, the Destructor is restricted to the retarded delivery mode only.

The Mk 30 arming device is a M904E2 mechanical nose fuze which has been modified to serve only an arm/safe function. It is not intended to detonate on impact at the low impact velocities common to retarded delivery. Once the Mk 30 nose arming device has been armed by the required air travel, an electric firing signal from the Mk 42 firing mechanism in the tail well is required to detonate the weapon. If the Mk 30 has not been armed, an electric firing signal from the Mk 42 will initiate an explosive train but will not fire the main booster charge and the weapon will dud.

The Mk 42 is armed after a specific preflight selected delay by a self-contained electrolytic timer. The arming delays are of a higher classification and are contained in NAVORD OP 3529. Once armed, the Mk 42 is triggered by the movement of any target which causes a change in the magnetic field of the weapon. Power for the firing signal is provided by a battery integral to the Mk 42 and no electrical connections to the aircraft are necessary.

Four arming wires are rigged to the weapon. The Mk 30 in the nose and the tail fin release band are connected to the bomb arming solenoids. Two additional arming wires connect the tail fin with the Mk 30 in the nose and the Mk 42 in the tail. This prevents arming of either element unless the tail fins are open.

In the event of retard fin malfunction, the weapon may detonate on high velocity impact with hard surfaces.

See NAVORD OP 3529 for more detailed information.

PREFLIGHT CHECKS

Check that Mk 30 is set for 2-second arming delay. Stop screw must not be installed in the Mk 30 at the 2-second setting. Assure that setscrew which locks the Mk 30 in the nose well is either flush with the after edge of the setscrew hole or that rubber insert protrudes from the top of the setscrew. This ensures watertight integrity. A special watertight plug must also be installed in the cable well in place of standard shipping plug. Check arming vane, arming wire rigging, Fahnestock clips, and removal of warning tags.

WARNING

If observation window in the Mk 30 shows full red at any setting or if a white stripe shows at any setting other than 6 or 18 seconds, the arming device is armed or partially armed and must not be used.

If the arming wire is withdrawn from the Mk 42 firing mechanism either intentionally or accidentally, the Mk 42 will begin operation at the end of the preset functioning delay. This will result in a dud weapon if the Mk 30 arming device is SAFE or in a full scale detonation if the Mk 30 is armed. Notify EOD immediately of any improper handling or rigging of the weapon.

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Figure 2-9 (C) (Sheet 5)

Delivery Options

Fuzes in the M990 series are not authorized for retarded delivery. When M990 fuzes are used in Snakeye bombs and an option of retarded or unretarded delivery is required, a mechanical fuze must be installed in the nose for use in the retard mode. Mk 344/376 electric fuzes permit an option of retarded or unretarded delivery. See section on RETARDED VERSUS UNRETARDED DELIVERY. For more detailed technical information on electric fuzes, refer to NAVAIR 11-5A-17.

Arming Wires

Loss of an arming wire from a mechanical fuze will allow the fuze to arm while the weapon is still on the bomb rack. When the weapon is released, it can detonate dangerously close to the aircraft if subjected to bomb-to-bomb or bomb-to-aircraft collision.

Electric fuzes use the arming wire as a mechanical backup safety device to guard against stray voltage and will not arm upon withdrawal of the arming wire unless also charged by a voltage from the delivery aircraft at weapon release. VT elements (Mk 43 and M20) use arming wires as an alternate means of initiation and not as a safing device.

A proper preflight check can minimize the possibility of arming wire failure. Most mechanical fuze and VT element arming wire installations are simple to check. Electric fuzes in the tail well are more difficult to observe.

One of the most common causes of arming-wire loss from mechanical fuzes is faulty installation of the Fahnestock clips which hold the arming wire in the fuze. When properly installed, these clips will hold the arming wire securely at all carriage speeds up to the maximum authorized. Fahnestock clips are slipped over the free end of the arming wire and are snugged up against the arming vane. If they are missing or loose, the airstream may blow the arming wire free of the arming vane and permit the fuze to arm. If they are not snug against the arming vane, it is possible for them to whiplash in the airstream. This can result in a sheared arming wire.

Assure that there is no excess slack in the arming wire. An excessively long arming wire can be dangerous. It should closely follow the contour of the bomb body but should exert no strain on the bomb arming solenoid. The arming wire should extend through the arming vane no more than 3 to 4 inches.

Check that all warning tags and safety pins have been removed from the fuze and that desired delays or options have been selected.

For specific data on arming wire installation for all fuzes, refer to the Airborne Weapons/Stores Loading Manual.

CARRIAGE AND DELIVERY SPEED RESTRICTIONS

Each fuze illustration lists maximum carriage and delivery speeds. These are fuze-imposed restrictions only. There may be further restrictions due to bomb rack or weapon limitations. In no case should these limitations be exceeded.

Carriage speed limitations are usually imposed by the arming wires, but in certain cases, are the result of vibrations which occur in the bomb structure. Delivery speeds are imposed by the aerodynamic characteristics of the fuze. In certain fuzes, higher-than-authorized delivery speeds will destroy the arming vane or cause erratic or faulty arming. In general, both maximum carriage and delivery speeds are determined by safety considerations but, in certain cases, reliability is the governing factor.

Release speed limits are normally higher than the carriage speed restrictions. These higher speeds are authorized on the assumption that they will be experienced for only brief periods during each mission. The cumulative time spent at the maximum delivery speed should not exceed 15 minutes.

If maximum delivery or carriage speeds are exceeded, the fuzes may be armed or completely unreliable and should be dropped as soon as practicable. They should not be returned to a field or carrier.

Note that certain fuzes require a lower release speed than carriage speed (Mk 347 and Mk 346). In these cases, excessive release speeds can reduce fuze reliability, can cause a bypassing of the desired functioning delay time, or can result in excessive penetration of the weapon. Excessive penetration is undesirable because it minimizes the blast and cratering effect of the weapon. It becomes a major problem with low drag weapons fuzed for functioning delays of 50 milliseconds or more when released from high altitudes or at high speeds against soft targets. Excessive release speeds can also cause weapon breakup or deflagration of bombs fuzed for the longer functioning delays.

EARLY BURSTS

It is possible for a fuze to detonate immediately upon arming or at some time after arming but before that intended. This is known as an "early burst" and can result from fuze malfunction, bomb-to-bomb or bomb-to-aircraft collision, or from mutual interference between bombs with VT elements installed.

Early burst probability is highest in electric fuzes. The rate expected is about one out of one-thousand with the M990 E series or Mk 344/376 fuzes. When a VT element is used for initiation, the early burst probability for the combination increases significantly and may occur in about four out of every one hundred releases.

Early bursts can also occur with mechanical fuzes. Accurate test data are not available, but the probability of early burst with mechanical nose fuzes is estimated to be about one in

ten-thousand. This can result from bomb-to-bomb collision and can also be caused by mechanical malfunction. Most mechanical fuzes require longitudinal impact and are therefore less susceptible than electric fuzes to detonation from bomb-to-bomb collisions. Careful observance of installation procedures will keep the possibility of mechanical malfunction to a minimum.

An early burst does not present a hazardous situation if fuzes and arming delays are selected with careful consideration of the type of bomb and delivery mode involved.

FUZE SAFETY AND RELIABILITY CONSIDERATIONS

Fuzes have two basic functions. The first is to maintain the weapon in the safest possible condition until the instant that detonation is desired. The second is to assure reliable and timely detonation of the weapon. Achievement of these two goals requires carefully balanced compromise and it is important that delivery pilots understand the implications of this relationship. Two distinct factors must be considered to assure maximum safety in weapon delivery. They are "safe-escape distance" and "safe-separation time."

Safe-Escape Distance

Safe-escape distance is the minimum acceptable distance, measured in feet, between the aircraft and the bomb at the time of intended detonation. Except for bombs fuzed to airburst, intended detonation is usually considered to occur at impact. As a general prudential rule, the functioning delay settings provided by the fuze should not be relied upon in computing safe-escape distances. Under conditions such as high-velocity impact on hard targets, a bomb can detonate immediately on impact regardless of the functioning delay set in the fuze. Safe-escape distance is an important factor in determining minimum release altitude.

Safe-Separation Time

Safe-separation time is the minimum acceptable separation, measured in seconds, between the aircraft and the weapon at the instant the fuze arms. This separation is necessary to protect the delivery aircraft from fragmentation damage in the event of an early burst. The minimum safe-separation time is dependent upon such obvious factors as delivery maneuver, speed, size of the bomb, and size of the aircraft. A factor not so obvious is release altitude. Due to reduced air density, an early burst at high altitude will produce a larger fragmentation envelope than at lower altitudes.

Minimum Arming Time

A factor which must be considered in determining the minimum safe separation time is the early burst probability of the specific fuze being employed. For example, if a fuze has a relatively high probability of early burst, it is mandatory that the safe-separation time be meticulously observed. Conversely, if a fuze has no tendency to early burst, there is no requirement to observe any safe-separation limits in the delivery tactics. Unfortunately, there are no fuzes which will assure a zero probability of early burst.

As a consequence, minimum arming times with various weapons and delivery maneuvers have been established. They are based upon a combination of safe-separation limits and early burst probability. The product of these two factors will determine whether the risk of fragmentation damage to the aircraft is within acceptable limits. Figure 2-10 indicates the minimum safe arming times to be observed when using Mk 344/376 electric fuzes and M904E mechanical fuzes in various authorized bombs. Data is presented for retarded and unretarded delivery under various types of delivery tactics.

Minimum Release Altitude

In addition to the limits imposed by bomb fragmentation and terrain clearance, minimum release altitudes are also imposed by the fuze. Very simply, the fuze must be released at a sufficient distance above ground level to permit arming. This is a straightforward computation; however, pilots must take into consideration the tolerances or variations in arming times for each specific fuze. As an example, arming delay times for M990E series fuzes can vary from −10% to +20% of the nominal specified arming time. Thus, a nominal 5.5-second arming delay could range anywhere from 4.9 to 6.6 seconds and to assure detonation, at least 6.6 seconds time of fall must be allowed.

Retarded Versus Unretarded Delivery

Minimum arming times and safe escape distances are considerably lower for retarded delivery than for unretarded delivery. For a fuze to be compatible with both types of delivery, it must permit selection of the proper arming time for each type of delivery and also contain a self-dudding capability in the event the weapon fails to retard. Without these safeguards, an early burst at the short arming times used with retarded delivery would very likely result in damage to the delivery aircraft if the Snakeye fins did not open. Similarly, a Snakeye fin failure during a low level, high speed release could result in the bomb impacting and detonating directly beneath the aircraft with disastrous results.

M990 series electric fuzes do not contain these safeguards and are not authorized for retarded delivery. Mechanical nose fuzes may be used in the retard mode but they must be interconnected with the Snakeye fin by an additional arming wire so that the fuze will remain safe in the event the fins fail to open. Should the fins open but then separate from the weapon, the bomb will usually tumble, thus increasing the arming time or dudding the nose fuze as well as increasing the separation distance from the aircraft.

The only fuzes which will permit an in-flight option of retarded or unretarded delivery are the Mk 344 and Mk

Minimum Safe Arming Times and Speeds

TACTIC		MIN REL SPEED (KTAS)	MINIMUM SAFE ARMING TIMES (SECONDS)									
			NON-VT MODE					VT-MODE (See Note 1.)				
			81	82	83	84	117	81	82	83	84	117
DIVE-TOSS	Any Stik Length	400	4.0	4.0	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5
Dive Unretarded with 4g Pullup (See Note 2.)	Single Release or Zero Stik Salvo (100 ms or less)	350	5.5	5.5	5.5	5.5	5.5	5.5	5.5	10	10	5.5
		450	4.0							5.5	5.5	
		over 45° dive	5.5							5.5	10	
	Multiple Release (1-second stik)	350	5.5	5.5	5.5	6.0	5.5	10	10	10	10	10
		450			5.5		5.5	5.5	5.5			
		over 45° dive			6.0		6.0	10	10			
	Multiple Release (2-second stik)	350	5.5	6.0	8.0	8.0	6.0	10	10	10	10	10
		450	5.5	6.0			6.0					
		over 45° dive	6.0	8.0			8.0					
Level Unretarded with Straight Ahead Recovery	0 to 5,000 ft (MSL)	350	8.0	8.0	8.0	10	8.0	10	10	10	10	10
		450	5.5			8.0						
	6,000 to 10,000 ft (MSL)	350	8.0	8.0	10	10	8.0	10	10	10	NA	10
		450			8.0						10	
	Over 10,000 ft (MSL)	350	8.0	8.0	10	10	10	10	10	NA	NA	NA
		450					8.0			10		10
Retarded Dive or Level with 4g Pullup (See Note 2.)	Multiple Release Mk 81/82 (1-second stik)	M 990 series fuzes not authorized in retarded mode. 2-second arming delay may be safely used with M904 series fuzes only if fuze and Snakeye fin are interconnected with an arming wire and release speed is at least 450 KTAS. Mk 344/376 fuzes automatically select 2.6-second arming delay upon sensing retardation provided release speed is 400 KIAS or greater.										

INSTRUCTIONS FOR USE OF CHART

a. Determine minimum safe arming time for the type of delivery, release speed, and weapon to be used. These times will result in not more than a 10% probability of aircraft receiving a fragment hit in the event of an early burst. Use of arming times as little as 1 second shorter than those listed can increase hit probability to 100%.

b. The arming times available with current fuzes are listed below for ready cross reference:

Fuze	Arming Delays
Mk 344	2.6-ret., 5.5-unret.
Mk 376	2.6-ret., 10.0-unret.
M904E2/E3	2,4,6,8,10,12,14,16,18
M990 E1	5.5
M990 E3	10.0
M990 E4	5.5

c. In all cases, refer to appropriate Sight Angle Charts to be sure that the planned release altitude will provide sufficient time-of-fall to permit the fuze to arm.

d. Observe minimum release intervals prescribed in the External Stores Limitation Charts to minimize probability of bomb-to-bomb collisions.

NOTES

1. Refer to M20 or Mk 43 illustrations for minimum release interval when delivery is in the VT mode.
2. Arming times are computed on the basis that aircraft will be established in a 4g pullup within 2 seconds after release of the specified stick length.

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Figure 2-10 (U)

376. Both fuzes provide safe arming times for retarded delivery. In addition, the Mk 344 provides safe arming delay for unretarded dive delivery; the Mk 376 provides safe delay for unretarded straight and level delivery. Both of these fuzes contain a special circuit which ensures increased safety in the event of Snakeye fin failure.

If Mk 344/376 fuzes are not available and a pilot option of retard or unretarded delivery is required, it is necessary to employ dual fuzing. For the longer delay required for unretarded releases, a M990 series fuze is installed in the tail. A mechanical nose fuze, rigged as noted above, is used for the short delay required for the retarded option. For retarded delivery, the AWW-2A Fuze Function Control Set must be set to SAFE.

Dual Fuzing

Dual fuzing may be employed either as a means of providing an in-flight option of arming times or to increase reliability. See section on Retarded Versus Unretarded Delivery for an example of a dual fuzing option.

As a method of increasing reliability, a nose and a tail fuze with essentially the same arming and functioning delays may be installed. Both fuzes are released armed and the probability of a dud is reduced. This procedure is normally used with firebombs with two fuzes of the identical type. With the current inventory of fuzes, the only combination which would reasonably serve this purpose with GP bombs would be an electric tail fuze and an M904E2/3 nose fuze. In view of the high reliability of both of these fuzes and the added effort required to install two fuzes, the advantage of the dual fuzing for this purpose alone is questionable unless near 100% reliability is an absolute tactical necessity.

SUMMARY

Delivery of weapons with an in-flight option of delivery modes will be safer and more effective if the following points are understood:

a. Operations with retarded weapons present a special hazard due to the possibility of Snakeye fin malfunction or pilot error.

b. When Snakeye weapons are inadvertently released unretarded or the fins fail to open properly, the bomb is, for all intents and purposes, unretarded. Under these conditions, the bomb will follow closely beneath the aircraft for a considerable period of time. With the bomb fuzed for arming times normal to retarded delivery, an unacceptable safe separation hazard will exist and a very critical safe escape situation will occur at impact.

c. Use of the M990 series electric fuzes in the retarded mode creates an unacceptable risk. The Mk 344/376 are the only electric fuzes which can be safely delivered in the retard mode.

d. Short arming times (2 seconds) with mechanical fuzes, while potentially dangerous, are acceptable in the retarded mode due to lower probability of early burst. In addition, complete separation of a Snakeye fin from the bomb will usually cause the bomb to tumble and thus increase the arming time of a mechanical fuze.

e. Longer arming times (5.5 seconds or greater) and proper delivery maneuvers are required in most cases for safe unretarded dive delivery.

f. For straight-and-level unretarded releases, a minimum arming delay time of 8 seconds is necessary to provide safe separation.

FUZE SELECTION

The conditions outlined above combine to make the task of selection and use of fuzes quite complex. With any given fuze, safe-separation times will vary greatly with the size and type of bomb, altitude and speed of release, and delivery maneuver. For these reasons, not all fuze-bomb combinations are safe under all conditions. The characteristics of each fuze and its companion bomb must be carefully studied and fully understood. See figure 2–11.

REFERENCES

For a more detailed study of bomb fuzes and their uses refer to the following:

Aircraft rockets	NAVAIR 11-85-5 (OP 2210/2626)
Arming wire installation	NAVAIR 01-4AA-75
Details of bombs and accessories	NAVAIR 11-5A-17
Details of fuzes and accessories	NAVAIR 11-5A-17 (OP 2216 Part 2)
Loading instructions	NAVAIR 01-45AA-75
Crew preflight	Stores Reliability Cards*

*NAVAIR 01-45HH-75-2 series, NAVAIR 01-45HH-75-3 series, NAVAIR 01-45HH-75-14 series

All data deleted from page 2–58D.

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MINIMUM AUTHORIZED ARMING TIMES AND SPEEDS FOR F8 AIRCRAFT

The arming times listed below are the minimum authorized for the combination of fuzes, bombs, release speeds and delivery tactics indicated. These arming times are based upon the following safety criteria:

1. THE PROBABILITY OF A FRAGMENT HIT ON THE DELIVERY AIRCRAFT IN THE EVENT OF AN EARLY BURST AT FUZE ARMING WILL NOT EXCEED 1 IN 10,

and

2. THE OVERALL PROBABILITY OF A FRAGMENT HIT PER EACH BOMB DROPPED WILL NOT EXCEED 1 IN 10,000.

Any deviation from these arming times must be approved by the OTC. See figure 2 for the method of computing fragment hit probabilities.

TACTIC		MIN REL SPEED (KTAS)	M904 E2 FUZES					MK 344/376 and M990 E (NON-VT)					VT MODE See Note 1				
			81	82	83	84	117	81	82	83	84	117	81	82	83	84	117
DIVE-TOSS	Any Stik Length	400	4.0	4.0	6.0	6.0	6.0	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5
DIVE UNRETARDED with 4g pull-up See Note 2	Single Release or Zero Stik Salvo (100 ms or less)	350	6.0	6.0	6.0	6.0	6.0	5.5	5.5	5.5	5.5	5.5	5.5	5.5	10	10	5.5
		450	4.0	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	5.5	5.5	↓
		Over 45° Dive	6.0	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	10	↓
	Multiple Release (1 second Stik)	350	6.0	6.0	6.0	6.0	6.0	5.5	5.5	5.5	10	5.5	10	10	10	10	10
		450	↓	↓	↓	↓	↓	↓	↓	10	↓	10	5.5	5.5	↓	↓	↓
		Over 45° Dive	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	10	10	↓	↓	↓
	Multiple Release (2 second Stik)	350	6.0	6.0	8.0	8.0	6.0	5.5	10	10	10	10	10	10	10	10	10
		450	↓	8.0	↓	↓	↓	10	↓	↓	↓	↓	↓	↓	↓	↓	↓
		Over 45° Dive	↓	↓	↓	↓	8.0	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
LEVEL* UNRETARDED with Straight Ahead Recovery See Note 3	0 to 5000 ft. (MSL)	350	8.0	8.0	8.0	10	8.0	10	10	10	10	10	10	10	10	10	10
		450	6.0	↓	↓	8.0	↓	5.5	↓	↓	↓	↓	↓	↓	↓	↓	↓
	6000 to 10,000 ft. (MSL)	350	8.0	8.0	10	10	8.0	10	10	10	NA	10	10	10	10	NA	10
		450	↓	↓	8.0	↓	↓	↓	↓	↓	10	↓	↓	↓	↓	10	↓
	10,000 ft to 15,000	350	8.0	8.0	10	10	10	10	10	10	10	10	10	10	NA	NA	NA
		450	↓	↓	↓	↓	8.0	↓	↓	↓	↓	↓	↓	↓	10	↓	10

RETARDED Dive or Level with 4g pull-up See Note 2	Multiple Release Mk 81/82 (1 second Stik)	M 990 series fuzes not authorized in retarded mode. 2 second arming delay may be safely used with M904 series fuzes only if fuze and Snakeye fin are interconnected with an arming wire and release speed is at least 450 KTAS. Mk 344/376 fuzes automatically select 2.6 second arming delay upon sensing retardation provided release speed is 400 KIAS or greater.
JETCONLABS	Multiple Release	Use the same arming delay times listed under DIVE UNRETARDED for the stik length, release speed and weapon to be delivered. Minimum safe arming times are based on recovery by Half-Cuban-Eight manuever.

INSTRUCTIONS FOR USE OF CHART

A. Determine minimum authorized arming time for the type of delivery, release speed and weapon to be used.

B. The arming times available with current fuzes are listed below for ready cross reference:

FUZE	ARMING DELAYS
Mk 344	2.6-Ret., 5.5-Unret.
Mk 376	2.6-Ret., 10.0-Unret.
M904E2/E3	2,4,6,8,10,12,14,16,18
M990 E1	5.5
M990 E3	10.0
M990 E4	5.5

C. In all cases, refer to appropriate bomb tables to be sure that the planned release altitude will provide sufficient time-of-fall to permit the fuze to arm.

D. Observe minimum release intervals prescribed in the External Stores Limitation Charts to minimize probability of bomb-to-bomb collisions.

E. In those cases marked "NA", no safe arming delay time is available.

NOTES:

1. Refer to M20 or Mk 43 Summary Sheets for minimum release interval when delivery is in the VT mode.
2. Arming times are computed on the basis that aircraft will be established in a 4g pull-up within two seconds after release of the specified stik length.
3. A sharp climbing manuever initiated immediately after last bomb released will reduce the probability of a fragment hit.

FIGURE 1

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COMPUTATION OF PROBABILITIES OF FRAGMENT HITS FROM EARLY BURSTS

The OTC may approve deviations to the Minimum Authorized Arming Times prescribed in figure 1 when the tactical advantage to be realized by use of shorter arming times will justify the added risk which will result. Deviations should be approved only when the prescribed arming times will substantially limit or degrade mission effectiveness. It is recommended that deviations be approved only when using M904E2/3 mechanical nose fuzes. The very low probability of early burst of this series fuze may permit use of lower arming times under certain tactical situations without increasing the overall risk above that warranted by the mission involved. In any case, it must be recognized that an early burst at low arming times will not only increase the probability of a fragment hit but will also increase the severity of damage in the event of a hit.

WARNING

The Minimum Authorized Arming Times prescribed in figure 1 are computed on the basis that the probability of a fragment hit on the delivery aircraft in the event of an early burst ($P_{H/EB}$) must not exceed 1 in 10 (.10) and, in addition, the overall probability of a fragment hit per each bomb dropped (P_H) must not exceed 1 in 10,000 (.0001).

When deviations to this safety criteria are necessary, latitude may be exercised in accepting higher values of $P_{H/EB}$ but the established limit of P_H of 1 in 10,000 must not be exceeded.

The method of computing fragment hit probabilities is as follows:

1. To compute the probability of a fragment hit per each bomb dropped (P_H), it is necessary that the early burst probability of the fuze being used (P_{EB}) be multiplied by the probability of a fragment hit in the event of an early burst ($P_{H/EB}$). This relationship is shown in the following formula;

$$P_H = P_{EB} \times P_{H/EB}$$

2. The estimated probability of an early burst (P_{EB}) of current fuzes is as follows:

FUZE	PROBABILITY OF EARLY BURST (P_{EB})	
M904E2/3	1 in 100,000	(.00001)
MK 344/376	1 in 1,000	(.001)
M990 E series	1 in 1,000	(.001)
MK 43/M20 VT elements	3 in 100	(.03)

NOTE

The above data are derived from range testing as updated by ordnance expenditure and incident reports.

3. The probability of the delivery aircraft receiving at least one fragment hit in the event of an early burst at arming ($P_{H/EB}$) for various arming times, bombs and delivery tactics is as follows:

TACTIC		MIN REL SPEED (KTAS)	PROBABILITY OF FRAGMENT HIT IN EVENT OF EARLY BURST ($P_{H/EB}$) F8 AIRCRAFT																			
			MK 81				MK 82				MK 83				MK 84				M 117			
			4	5.5	6	8	4	5.5	6	8	4	5.5	6	8	4	5.5	6	8	4	5.5	6	8
DIVE-TOSS	Any Stik Length	400	.04	.00	.00	.00	.09	.00	.00	.00	.27	.00	.00	.00	.47	.00	.00	.00	.21	.00	.00	.00
DIVE UNRETARDED with 4g pull-up	Single Release or Zero Stik Salvo (100 ms or less)	350	.20	.00	.00	.00	.46	.00	.00	.00	.78	.00	.00	.00	.97	.01	.00	.00	.73	.00	.00	.00
		450	.10	↓	↓	↓	.35	↓	↓	↓	.71	↓	↓	↓	.93	.00	↓	↓	.64	↓	↓	↓
		Over 45° Dive	.29	↓	↓	↓	.57	↓	↓	↓	.90	↓	↓	↓	.99	.01	↓	↓	.91	↓	↓	↓
	Multiple Release (1 second Stik)	350	.98	.01	.00	.00	1.00	.02	.00	.00	1.00	.09	.01	.00	1.00	.19	.02	.00	1.00	.05	.00	.00
		450	.99	.00	↓	↓	↓	.00	↓	↓	↓	.06	.00	↓	↓	.12	.01	↓	↓	.03	↓	↓
		Over 45° Dive	1.00	.01	↓	↓	↓	.04	↓	↓	↓	.19	.01	↓	↓	.34	.02	↓	↓	.15	.01	↓
	Multiple Release (2 second Stik)	350	1.00	.10	.01	.00	1.00	.30	.04	.00	1.00	.57	.14	.00	1.00	.82	.27	.00	1.00	.52	.11	.00
		450	↓	.08	.01	↓	↓	.25	.02	↓	↓	.53	.11	↓	↓	.78	.21	↓	↓	.44	.05	↓
		Over 45° Dive	↓	.56	.07	↓	↓	.77	.23	↓	↓	.98	.44	↓	↓	1.00	.69	↓	↓	.95	.41	↓
LEVEL UNRETARDED with Straight Ahead Recovery	0 to 5000 ft. (MSL)	350	1.00	.34	.16	.00	1.00	.69	.43	.01	1.00	.99	.75	.07	1.00	1.00	.94	.14	1.00	.95	.76	.22
		450	.99	.11	.04	↓	↓	.43	.18	.00	↓	.86	.61	.01	↓	.99	.84	.02	↓	.67	.32	.00
	6000 to 10,000 ft. (MSL)	350	1.00	.76	.41	.01	1.00	.92	.68	.04	1.00	1.00	.98	.16	1.00	1.00	1.00	.29	1.00	.99	.92	.15
		450	↓	.29	.14	.00	↓	.68	.44	.01	↓	.99	.80	.08	↓	↓	.96	.15	↓	.93	.63	.03
	10,000 ft to 15,000	350	1.00	.90	.65	.04	1.00	.97	.85	.12	1.00	1.00	1.00	.27	1.00	1.00	1.00	.47	1.00	1.00	.96	.31
		450	↓	.67	.27	.00	↓	.88	.58	.02	↓	↓	.97	.17	↓	↓	↓	.30	↓	.98	.83	.08

Figure 2

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Bomb-Fuze Combinations

CAUTION

(C) This chart is intended for ready reference only. Users must refer to individual fuze Summary Sheets and Minimum Safe Arming Time chart for limitations and restrictions on specific combinations. Safe usage of most fuzes depends upon type of delivery and arming times selected.

FUZE		GENERAL USE STORES							COMMENTS
		LDGP					Retard		
Nose Fuzes	Type	Mk 81	Mk 82	Mk 83	Mk 84	M 117	Mk 81	Mk 82	
Mk 347	M	SP	SP	X	X	X	SP	SP	Low speed, retarded delivery
M904E2/E3	M	P	P	P	P	P	P	P	
M1A1 Fuze Extension (Daisycutter)	M	SP	SP	SP	SP	X	X	X	Use only with fuzes set for INST functioning delay.
VT Elements									
M20/20A1	E	SP	SP	SP	SP	SP	O	O	These VT elements are compatible with and must be used with any of the current electric tail fuzes.
Mk 43	E	SP	SP	SP	SP	SP	SP	SP	
Tail Fuzes									
Mk 344	E	P	P	P	P	P	P	P	For dive delivery – retarded or unretarded
Mk 376	E	P	P	P	P	P	P	P	For retarded dive or unretarded level delivery.
Mk 346	M	SP	SP	SP	O	O	SP	SP	Long delay
M990E-1/E-3/E-4	E	A	A	A	A	A	O	O	Not authorized for retarded delivery

FUZE			SPECIAL PURPOSE STORES				
			CBU	Fire Bomb		Rockeye	Dst
Special Use	Location	Type	24/29/49 /B,/B Mod A/B,C/B	Mk 77-2	Mk 77-4	Mk 20	Mk 36
AN-M 173A1	N/T/S	M	O	P	A	O	O
M918	S	M	O	O	P	O	O
Mk 339	N	M	O	O	O	P	O
M904E2/E3	N	M	O	O	O	O	O
M907E1/E2	N	M	P	O	O	O	O
Mk 30 arming device Mk 42 firing mechanism	N T	M E	O	O	O	O	P

KEY TO SYMBOLS

Fuze Type and Location
- M – Mechanical
- E – Electric
- N – Nose
- T – Tail
- S – Side

Bomb-Fuze Combinations
- P – Preferred usage
- A – Alternate usage
- SP – Special purpose
- X – Physically compatible but not tested for this application
- O – Either not physically or functionally compatible

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Figure 2–11 (C)

ROCKET FUZES

CLASSIFICATION

Rocket fuzes are classified according to their location in the warhead, the type of action required to arm the fuze and the method of detonation. With the exception of the Mk 191 fuze which is installed and sealed in the base of the Mk 24 Zuni warhead, all current aircraft rocket fuzes are nose mounted.

FUZE ARMING METHODS

Acceleration

All current 2.75- and 5.0-inch FFARS use a combination acceleration plus time for arming. The acceleration (setback) created upon rocket firing causes a weight within the fuze to move aft and initiate the arming cycle. These fuzes also incorporate a timing gear train which provides a constant arming distance regardless of variations in rocket thrust. (40g's of acceleration for about 1 second are required to arm the fuze. These fuzes do not utilize arming wires and the pilot has no control over fuze operation.) The variations in arming distance shown in the tables are due to manufacturing tolerances and temperature effects on the mechanism.

Motor Burnout (Creep)

In order to provide additional safety in nonimpact type fuzes (VT and time), a special feature is included which maintains the fuze in a safe condition until rocket motor thrust ceases. At the end of the acceleration period, a spring-loaded mechanism causes the weight to shift forward and complete the arming cycle. This feature is similar to creep used in older fuzes. In creep mechanisms, the normal deceleration caused by aerodynamic drag completes the arming cycle rather than the more positive spring action used in the newer fuzes.

FUZE FUNCTIONING METHODS

Three methods are used to initiate detonation of the 2.75- and 5.0-inch rocket fuzes. They are impact, VT, and mechanical time.

Impact

Impact fuzes are designed to detonate on impact either instantaneously or after a short delay. Due to the high velocity of aircraft rockets, the functioning delays used in rockets are much shorter than those in bomb fuzes. Many rocket fuzes are relatively insensitive and will not detonate on impact with water. Impact nose fuzes are designated as point detonating (PD), and base impact fuzes as base detonating (BD).

VT Fuze

The Mk 93 (M414A1) is the only VT fuze now available for use in jet aircraft. It is installed only in Zuni warheads. The fuze utilizes a small radio transmitter/receiver similar to those in VT bomb fuzes for ranging on the target and initiating detonation. The sensitivity of the VT element has been reduced to preclude mutual interference between rockets when ripple fired. As a result, the fuze will not sense aircraft targets and is to be used only in the air-to-ground mode. Due to the orientation of the sensing lobe pattern, proper ranging requires an impact angle between 20 and 40 degrees. The insensitivity of the VT element and the motor burnout feature provide adequate safe-separation from the firing aircraft.

Mechanical Time

The Mk 193 is the only aircraft rocket fuze now available for jet aircraft which will provide a timed airburst. It is installed only in the Mk 33 flare head in the Zuni rocket. This fuze uses a simple clockwork timer to initiate detonation and incorporates the motor burnout feature. The time delay commences at rocket firing.

ASSEMBLY PROCEDURES

2.75 FFAR

All 2.75 rockets currently in use are shipped with the rocket body, warhead and fuze completely assembled. These rockets are delivered to the using activity loaded in the appropriate launcher pod. The launcher is sealed with metallic foil as a protection against RADHAZ. As a result, pilots will rarely have the opportunity to observe or inspect a 2.75 rocket.

5.0 FFAR (Zuni)

The 5.0-inch Zuni rocket is delivered with the rocket body, warhead and fuze disassembled. The only exception is the Mk 24 warhead which has a base fuze installed and sealed at the depot. Various combinations of warheads and fuzes are assembled by the user.

WARHEAD/FUZE COMBINATIONS

Figure 2–12 lists the authorized fuze/warhead combinations and essential data relating to their use.

PREFLIGHT OF ORDNANCE AND HARDWARE

The following ordnance preflight items should be checked by the pilot during the walk-around inspection. For more detailed information on preflight items, consult NAVAIR 01-45HHC-75, Weapons/Stores Loading Manual, Applicable Conventional Weapons Loadings Checklist, and Stores Reliability Cards (SRC).

CAUTION

Prior to any ordnance preflight ensure that all cockpit armament switches are in the OFF and SAFE position.

WING PYLONS AND AERO 7A OR 7A-1 ER (Applies to All Ordnance Carried)

1. Safety pin	INSTALLED
2. SEAR indicator	BLACK MARKS IN LINE
3. Ejector foot	BACKED OFF STORE TO FIRST DETENT
4. Tripe-multiple rack fire mode switch	AS DESIRED (Single or dual)
5. Fuzing switch	AS APPROPRIATE—(MECHANICAL OR ELECTRICAL) (BOMBS only)

ORDNANCE LOADED DIRECTLY ON AERO 7A OR 7A-1 (In Addition to Wing Pylon and AERO 7A Preflight)

Bombs

1. Security	AERO 7A-1 sway braces — TIGHT
2. Fuzing	Mechanical – ARMING WIRES PROPERLY ROUTED BETWEEN FUZES AND NOSE/TAIL SOLENOID Electrical — ELECTRICAL ARMING PLUG WITH WAFER SWITCH SEATED INTO BOMB
3. Snakeye fin	Non-retarded – FIN RELEASE BAND INSTALLED AND SAFETIED Retarded – FIN RELEASE WIRE ROUTED FROM PYLON SOLENOID TO FIN RELEASE BAND FASTENER. FUZE ARMING WIRE FROM FORWARD PART OF A FIN BLADE TO MECHANICAL FUZE. FIN RELEASE WIRES SHOULD BE ROUTED THROUGH GUIDE TUBE. (Fuze arms only with open tail fin.)

Rockets:

1. Security	AERO 7A-1 – SWAY BRACES TIGHT
2. Safety devices	INSTALLED/POSITIONED TO SAFE
3. Launcher fire mode switch	AS DESIRED (Single or ripple)

MER OR TER PREFLIGHT (In Addition to Pylon and AERO 7A-1 Preflight)

1. Safety pin(s)	INSTALLED IN MER/TER TAIL CONE AND EACH LOADED STATION.
2. Security	AERO 7A-1 sway braces TIGHT on MER/TER. MER/TER sway braces TIGHT on store.
3. MER/TER release mode switch	AS DESIRED (Single or Dual setting)
4. MER/TER pylon switch	BOMBS or ROCKETS
5. MER/TER empty station hooks	OPEN
6. Fuzing	Mechanical – ARMING WIRES PROPERLY ROUTED FROM MER/TER SOLENOID TO EACH FUZE Electrical – ELECTRICAL ARMING PLUG SEATED INTO EACH BOMB*
7. Snakeye fin	AS DESIRED NON-RETARDED – FIN RELEASE BAND INSTALLED AND SAFETIED

*On racks with Mk 39 receptacle, the Mk 122 arming safety switch coaxial cable and lanyard must be connected to each bomb rack.

Rocket Fuze/Warhead Combinations

FUZE LOCATION/TYPE	WARHEAD TYPE	FUZE ARMING	FUZE FUNCTIONING	REMARKS
		5.0" FFAR (ZUNI)		
Mk 93-0 (M414A1) Nose-VT	Mk 24 HE Mk 32 ATAP Mk 34 WP Smoke Mk 63 AP	Acceleration + Time + Burnout 1,000 ft	VT (Impact Backup) 20-60 ft burst height	20° to 40° impact angle required for air burst. Can be ripple fired.
Mk 188-0 Nose-Impact	Mk 24 HE Mk 32 ATAP Mk 34 WP Smoke	Acceleration + Time 400-800 ft	Impact (PD) Inst	To be replaced by Mk 352.
Mk 191-1 Base-Impact	Mk 24 HE	Acceleration + Time 475-670 ft	Impact (BD) 0.005 sec delay	Not reliable on water targets.
Mk 193-0 Nose-Time	Mk 33 Flare	Acceleration + Time + Burnout 1,000 ft	Mechanical Time 15 (+2, -1,) sec delay	No impact backup.
Mk 352 Nose-Impact	Same as Mk 188	Acceleration + Time 660-1,180 ft	Impact (PD) Inst	To replace Mk 188. Requires BBU 15B adapter for use in Zuni.
		2.75" FFAR		
Mk 176-1 Nose-Impact	Mk 1 HE	Acceleration + Time 400-1,350 ft	Impact (PD) 0.0003 sec delay	See note.
Mk 178-1/2 Nose-Impact	Mk 1 HE	Acceleration + Time 400-1,350 ft	Impact (PD) Inst	See note.
Mk 181-0 Nose-Impact	Mk 5 ATAP (Shaped Charge)	Acceleration + Time 330-660 ft	Impact (PD) Inst	See note. Shaped charge must impact between 30° and 90° of surface to be penetrated.
M 427 Mk 352 Nose-Impact	Mk 1 HE Mk 64 GP Mk 67 Smoke M 151 GP M 156 Smoke	Acceleration + Time 660-1,180	Impact (PD) Inst	Will detonate on water. Mk 352 more reliable than M427 for shallow angle impacts

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NOTE

Will not detonate on impact with water. Will not detonate at impact angles less than 10 to 15 degrees.

Figure 2-12 (U)

	RETARDED – FIN RELEASE WIRE ROUTED FROM MER/TER SOLENOID TO FIN RELEASE BAND FASTENER. FUZE ARMING WIRE ROUTED FROM FORWARD PART OF A FIN BLADE TO MECHANICAL FUZE. FIN RELEASE WIRE SHOULD BE ROUTED THROUGH GUIDE TUBE. (Fuze arms only with open tail fin.)
8. Rocket Launcher	RADHAZ – PIN INSTALLED. FIRE MODE SWITCH – Single or ripple.

MBR PREFLIGHT (In Addition to Pylon and AERO 7A-1 Preflight)

1. Safety pin	INSTALLED IN EACH MBR LOADING STATION
2. Security	AERO 7A-1 Sway Braces TIGHT on MBR. MBR Sway Braces – TIGHT on STORE.
3. MBR release mode selector	AS DESIRED (Single or intervalometer setting)
4. Fuzing	Mechanical – ARMING WIRES PROPERLY ROUTED FROM MBR SOLENOID TO FUZES
	Electrical – ELECTRICAL ARMING PLUG SEATED INTO EACH BOMB
5. Snakeye fin	AS DESIRED
	NON-RETARDED – TRUNK LATCH BAND INSTALLED AND SAFETIED. RETARDED – FIN RELEASE WIRE ROUTED FROM MBR SOLENOID TO FIN RELEASE BAND FASTENER. FUZE ARMING WIRE ROUTED FROM FORWARD PART OF A FIN BLADE TO MECHANICAL FUZE. FIN RELEASE WIRES SHOULD BE ROUTED THROUGH GUIDE TUBE. (Fuze is armed only with open tail fin.)

PMBR PREFLIGHT (In Addition to Pylon and AERO 7A-1 Preflight)

1. Arm safe switch	ARMED
2. Practice bomb or MK 24 Flare Security	SLIGHTLY LESS THAN RIGID
3. Intervalometer	POSITION 1
4. Fuzing (Mk 24 Flare)	ARMING LANYARD PROPERLY ROUTED. EJECTION AND IGNITION DELAY SET AS DESIRED.
5. Rocket ripple switch	AS DESIRED
6. Electrical lead	CONNECTED TO PMBR

FUSELAGE STATIONS PREFLIGHT

Zuni Rockets

1. Safety pins	INSTALLED ON EACH LAU-33A/A, -35A/A
2. Rocket launcher fire mode	AS DESIRED (Single or ripple)
3. Launcher positions	LAU-33A/A ON ALL STATIONS EXCEPT LOWER LEFT FUSELAGE STATION LAU-35A/A ONLY ON LOWER LEFT FUSELAGE STATION

Sidewinder — AIM-9B, AIM-9C, AIM-9D Preflight on Fuselage Stations

1. Safety pin	(LAU-7A or AERO-3A) INSTALLED

WARNING

When using LAU-7A launcher do not rotate safety pin after Sidewinder is loaded due to possible missile release during catapult launch.

2. Coolant air bottle	(LAU-7A ONLY) — GREEN AREA (3,000–3,500 psi, AIM-9D only)
3. Launchers	ALL SIDEWINDERS ON LAU-7A. AIM-9B ONLY ON AERO-3A.
4. Missile security	LAUNCHER RAIL STOPS ON BOTH SIDES OF MISSILE LUGS.
5. G and C section covers	REMOVED
6. Canard fins	PROPER MOVEMENT
7. Missile	NO EVIDENCE OF DAMAGE
8. Rollerons	CAGED and FREE ROLLING
9. Non-propulsion unit	REMOVED
10. G and C colored number	(AIM-9C only) MUST MATCH COLOR OF CRYSTAL OSCILLATOR ON STARBOARD CONSOLE OF COCKPIT

NAVIGATION

The navigation procedures recommended in this manual are not intended to cover all aspects and techniques possible in mission planning. The conventional attack mission may be conducted utilizing available navigation aids or dead reckoning or a combination of both.

The use of navigational aids such as TACAN and UHF vectoring by GCI sites, ship and forward air controllers is encouraged but should be backed with good dead reckoning navigation. The discussion presented here will deal with DR planning. Climb schedule, drag index, time/radius, and range constants charts are found in this section. Other cruise control data may be obtained from the REST computer and the NATOPS Flight Manual.

CHARTS

Large scale charts (1:1,000,000) are best suited for high altitude DR navigation. Area coverage is sufficient to permit reuse of the chart although the target and route may have changed.

Charts with greater detail, such as Pilotage Charts (1:500,000 scale) are considered best for low level DR navigation.

Aeronautical Approach Charts (1:250,000 scale) or Army Map Service Charts (1:50,000 scale) should be used for target area detail and close air support missions.

Accurate detailed maps are not available for some areas of the world. In such cases, a good sense of dead-reckoning is essential.

Intelligence and weather briefings should be obtained before selecting the exact route to be followed. The appropriate charts providing coverage between the home base and the target should be assembled so that the entire route may be seen.

Coastal Penetration

In most cases a coastal penetration will be required. Enemy defenses, inland terrain, and prominent or peculiar coastal landmarks influence entry point selection. The aircraft radar may be used when EMCON is not a factor and a radar prominent coastal feature, such as a bay or promontory, is available. To escape enemy detection, coastal penetration should be at minimum altitude, high speed, and on a course perpendicular to the coastline. A careful study should be made of the coastline for several miles either side of the selected penetration point (ten percent of the overwater distance) and a contingency plan formulated in case the exact penetration point is missed. The

selected penetration point should be easy to recognize by its geographical features. Such features as rivers and mountain chains can be used to funnel the flight onto the planned course.

Check Point Selection

Selection of check points will vary according to flight altitude and conditions of the terrain over which the flight will pass. At higher altitudes, such features as large lakes, rivers, towns, and distinctive mountain ranges rising from relatively flat surrounding terrain provide excellent navigation check points. At low altitude, check points should be selected that have some vertical development or a well-defined horizontal development perpendicular to the course, such as a river, railroad, or highway. Consideration must be given to seasonal changes that alter the appearance of natural check points. In winter, check points may be obliterated by snow cover, and in the spring, rivers may overflow their normal banks and conceal terrain features. An easily recognized, well-defined initial (or approach) point near the target may be necessary to help find the target. The retirement course from the target should consider the same factors as the inbound flight. Care must be taken to avoid those areas overflown while inbound as enemy defenses have been alerted.

Although check points should be selected with care to ensure accurate navigation, they should not be relied upon completely, Flying a planned time and heading is paramount and if at the end of a particular leg the selected check point cannot be found, it is recommended to turn at the planned time, take up the new course, and then attempt to correct back on course.

Chart Preparation

The following technique for marking charts is recommended:

a. Enclose check points in circles and the target in a triangle.

b. Connect succeeding check points with a straight line.

c. Enter magnetic heading, distance, and preplanned flight time between check points.

d. Note bingo fuel and time at each position where a bingo might be necessary.

e. Enter information, such as enemy defenses, divert fields, friendly forces, alternate targets and attack airspeed, altitude, dive angle, and armament switch reminders as necessary. A uniform and neat marking system will aid in exchanging charts between pilots. A flight log should be completed for a quick reference to other essential information.

Heading changes should be started at check points. The distance travelled during turns may be determined from the coin turn chart (figure 2–13). The edge of the selected coin should be placed on the course at the check point. The turn is then traced around the coin, and the new course is plotted directly to the new check point.

Charts may be prepared in various ways. Large charts can be accordian folded similar to the Flight Information Publications Charts. Low level charts should be cut in strips which show an area about 15 miles either side of course and 15 miles beyond a turning point. This strip can be accordion folded to kneeboard size or placed on a strip roller.

CRUISE CONTROL

GENERAL

The cruise control charts are designed to provide a quick method for determining the data needed when planning an attack mission profile. The data are presented in the following four types of charts and tables:

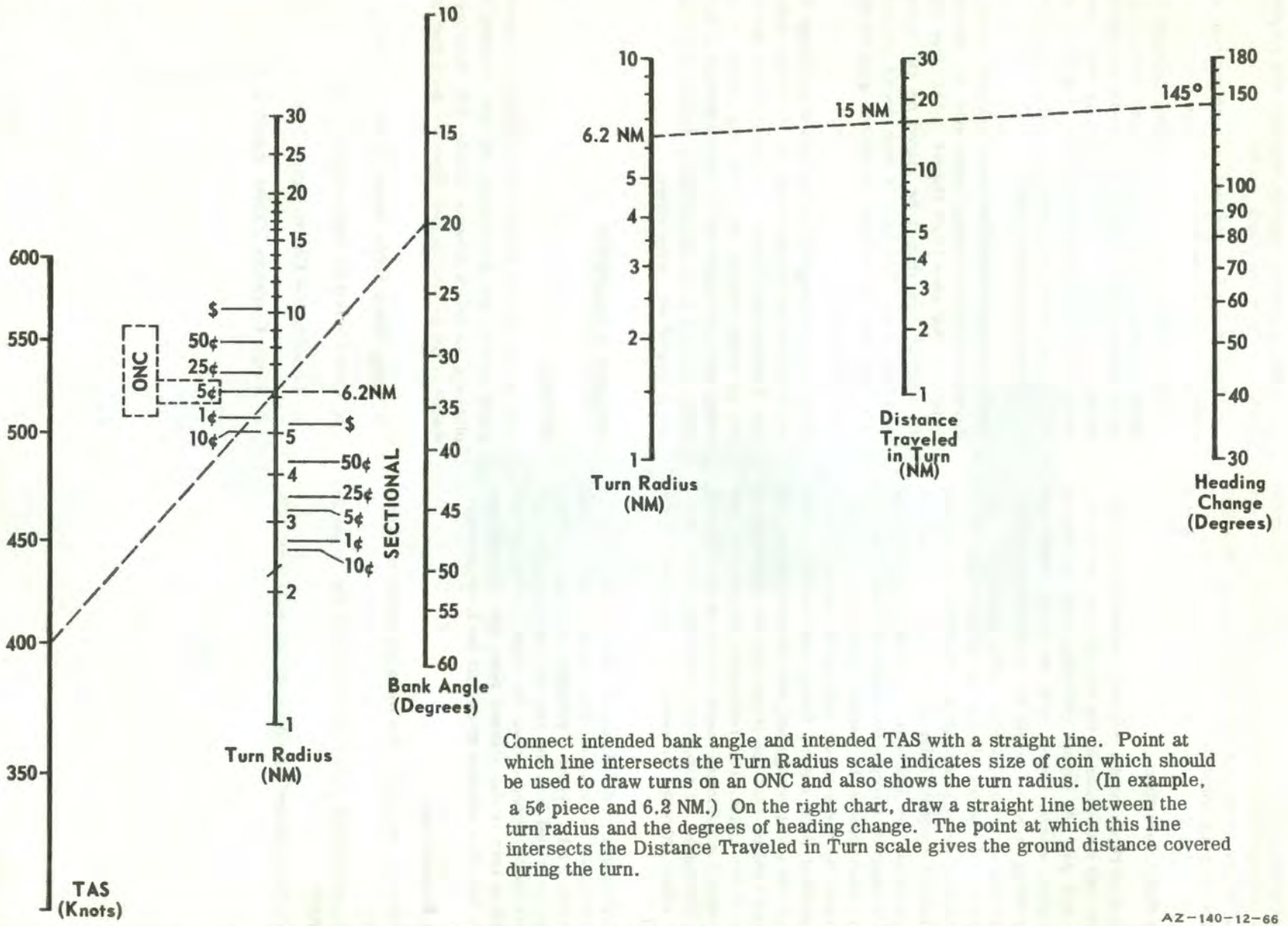
a. Drag Index Table, figure 2–14

b. Climb Schedule Table, figure 2–15

c. Time/Radius Charts, figure 2–16

d. Range Constants Tables, figure 2–17

Turn Chart



Connect intended bank angle and intended TAS with a straight line. Point at which line intersects the Turn Radius scale indicates size of coin which should be used to draw turns on an ONC and also shows the turn radius. (In example, a 5¢ piece and 6.2 NM.) On the right chart, draw a straight line between the turn radius and the degrees of heading change. The point at which this line intersects the Distance Traveled in Turn scale gives the ground distance covered during the turn.

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Figure 2-13

Drag Index

STORE		WEIGHT LB		INDIVIDUAL STORE DRAG
MK 24 Mod 3/4 Parachute Flare		27		6.3
MK 45 Mod 0 Parachute Flare		28		6.3
MK 76 Practice Bomb		24		1.5
MK 77 Fire Bomb	MOD 4		520	12.5
	MOD 2		520	9.5
MK 79 Fire Bomb	MOD 1		912	8.1
MK 81 LDGP Bomb		260		4.4
MK 81 Snakeye I GP Bomb		301		6.5
MK 82 LDGP Bomb		527		6.9
MK Snakeye I GP Bomb, MK 124 Practice, MK 36 Destructor		571		8.8
MK 83 LDGP Bomb		985		9.3
MK 84 LDGP Bomb		1970		13.9
MK 86 Practice Bomb		217		4.1
MK 87 Practice Bomb		333		6.8
MK 88 Practice Bomb		783		9.3
MK 89 Practice Bomb, Mods 0 and 1		57		0.7
M117A1		823		12.5
MK 20 Rockeye		460		15.5
CBU-24, -29, -49 Series		830		17
AERO 6A, 6A-1, 6A-2 Rocket Launcher*	F	148		1.3
	E	21		6.3
AERO 7D Rocket Launcher*	F	431		2.5
	E	95		13.0

STORE		WEIGHT LB	INDIVIDUAL STORE DRAG
LAU-3A/A Rocket Launcher*	F	417	2.5
	E	81	13.0
LAU-10A/A Rocket Launcher	E	105	12.5
Nose Cone on, Tail Cone off	F	533	8.3
Nose and Tail Cones off			
MK 32 Mod 0 Head on Rockets	F	533	19.5
MK 24 Mod 0 Head on Rockets	F	533	32.5
LAU-32A/A Rocket Launcher*	F	168	1.3
	E	47	6.3
LAU-32B/A Rocket Launcher*	F	168	1.3
	E	47	6.3
LAU-33A/A and -35A/A Rocket Launcher	E	48	6.8
MK 32 Mod 0 Head on Rockets	F	262	8.5
MK 24 Mod 0 Head on Rockets	F	262	14.0
LAU-56/A Rocket Launcher*	F	168	1.3
	E	47	6.3
LAU 60/A Rocket Launcher*	F	473	2.5
	E	79	13.0
LAU-61/A	F	542	6.5
	E	133	13.0
LAU-68/A	F	217	2.5
	E	67	6.5
LAU-69/A	F	506	6.5
	E	98	13.0
AIM-9B Missile		158	5.0
AIM-9C Missile		210	5.0
AIM-9D Missile		189	5.0

	SUSPENSION EQUIPMENT	DRAG PER STATION WGT/STA	1	2	3	4
CONVEN STORES	Wing Pylon and Aero 7A-1 EBR	227	10.5			10.5
	Wing Pylon, Aero 7A-1 ER and MBR	386	23.0			23.0
	Wing Pylon, Aero 7A-1 ER and MER	450	23.0			23.0
	Wing Pylon, Aero 7A-1 ER and TER	332	20.5			20.5
	Wing Pylon and Aero 7A-1 ER and PMBR	314	18.0			18.0
AIM-9	Single Fuselage Pylon and LAU-7/A Launchers	103		2.5	2.5	
	Dual Fuselage Pylon and LAU-7/A Launcher	252		7.5	7.5	
	Single Fuselage Pylon and AERO 3A Launcher	62		2.5	2.5	
	Dual Fuselage Pylon and Aero 3A Launchers	168		7.5	7.5	

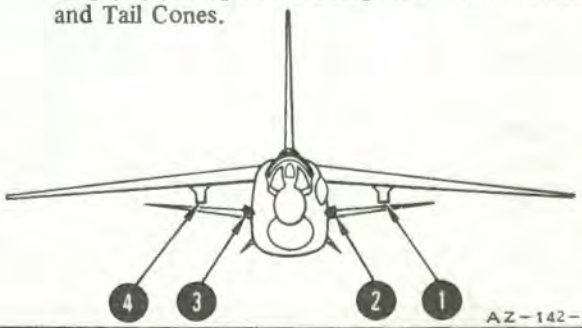
NOTE

The drag index of the clean airplane is zero.

Individual store drag x number of stores to be carried + suspension equipment drag = drag index.

Drag numbers for single stores are slightly conservative. Interference drag between multiple stores has been considered.

*Empty (E) Drag Index Computed Without Nose and Tail Cones.



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Figure 2-14

Climb Schedules

MILITARY POWER

Date: November 1966
Data Basis: Flight Tests

ENGINE: J57-P20A
ICAO STANDARD DAY

Fuel Grade: JP-5
Fuel Density: 6.8 Lb/Gal

DRAG INDEX

ALTITUDE	0			15			34			60		
	KCAS	KTAS	MACH	KCAS	KTAS	MACH	KCAS	KTAS	MACH	KCAS	KTAS	MACH
S.L.	480	480	.73	480	480	.73	480	480	.73	431	431	.65
5,000	450	480	.74	450	480	.74	450	480	.74	403	431	.66
10,000	421	480	.75	421	480	.75	421	480	.75	379	431	.68
15,000	392	480	.77	392	480	.77	392	480	.77	351	431	.69
20,000	363	480	.78	363	480	.78	363	480	.78	323	431	.70
25,000	337	480	.80	337	480	.80	337	480	.80	299	431	.72
30,000	312	480	.82	312	480	.82	312	480	.82	272	431	.73
35,000	285	480	.84	285	480	.84	285	480	.84	251	431	.75
40,000	255	480	.84	255	480	.84	255	480	.84	226	431	.75
45,000	228	480	.84	228	480	.84	228	480	.84			

DRAG INDEX

ALTITUDE	83			109			136			172		
	KCAS	KTAS	MACH	KCAS	KTAS	MACH	KCAS	KTAS	MACH	KCAS	KTAS	MACH
S.L.	407	407	.62	398	398	.60	388	388	.59	371	371	.56
5,000	381	407	.63	372	398	.61	365	388	.60	347	371	.57
10,000	366	407	.64	348	398	.62	339	388	.61	323	371	.58
15,000	330	407	.65	321	398	.64	315	388	.62	300	371	.59
20,000	306	407	.66	300	398	.65	290	388	.63	278	371	.61
25,000	280	407	.68	272	398	.66	267	388	.65	257	371	.62
30,000	259	407	.69	250	398	.68	244	388	.66	235	371	.63
35,000	238	407	.71	230	398	.69	224	388	.67			
40,000	210	407	.71	203	398	.69	200	388	.67			
45,000												

DRAG INDEX

ALTITUDE	199			225			251		
	KCAS	KTAS	MACH	KCAS	KTAS	MACH	KCAS	KTAS	MACH
S.L.	362	362	.55	354	354	.54	345	345	.52
5,000	349	362	.56	330	354	.55	321	345	.53
10,000	315	362	.57	308	354	.56	300	345	.54
15,000	293	362	.58	284	354	.57	277	345	.55
20,000	270	362	.59	264	354	.58	257	345	.56
25,000	251	362	.61	244	354	.59	237	345	.57
30,000	230	362	.62	225	354	.61	218	345	.59
35,000									
40,000									
45,000									

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Figure 2-15

Time/Radius Chart

TAKEOFF DRAG INDEX GROSS WEIGHT	
0	28,500 POUNDS

TYPICAL CONFIGURATION	
OUTBOUND	RETURN
Clean Airplane	Clean Airplane

CAUTION

This chart is invalid if the return configuration is not as stated for a typical configuration. Extreme deviation from the drag index gross weight combination can also prove this chart invalid.

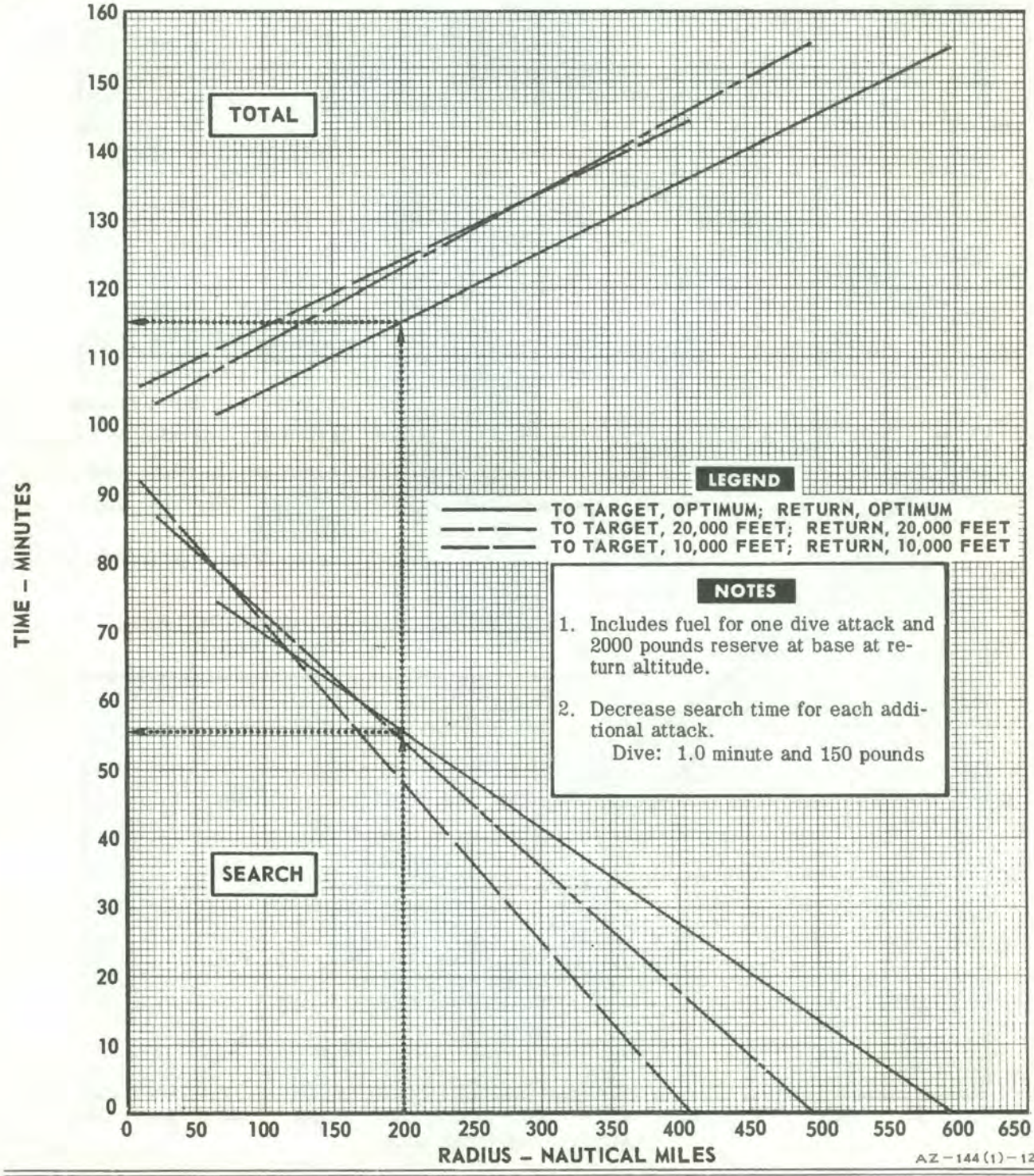


Figure 2–16 (Sheet 1)

Time/Radius Chart

TAKEOFF DRAG INDEX GROSS WEIGHT	
15	29,100 POUNDS

TYPICAL CONFIGURATION	
OUTBOUND	RETURN
(2) AIM – 9C's	(2) AIM – 9C's

CAUTION

This chart is invalid if the return configuration is not as stated for a typical configuration. Extreme deviation from the drag index gross weight combination can prove this chart invalid.

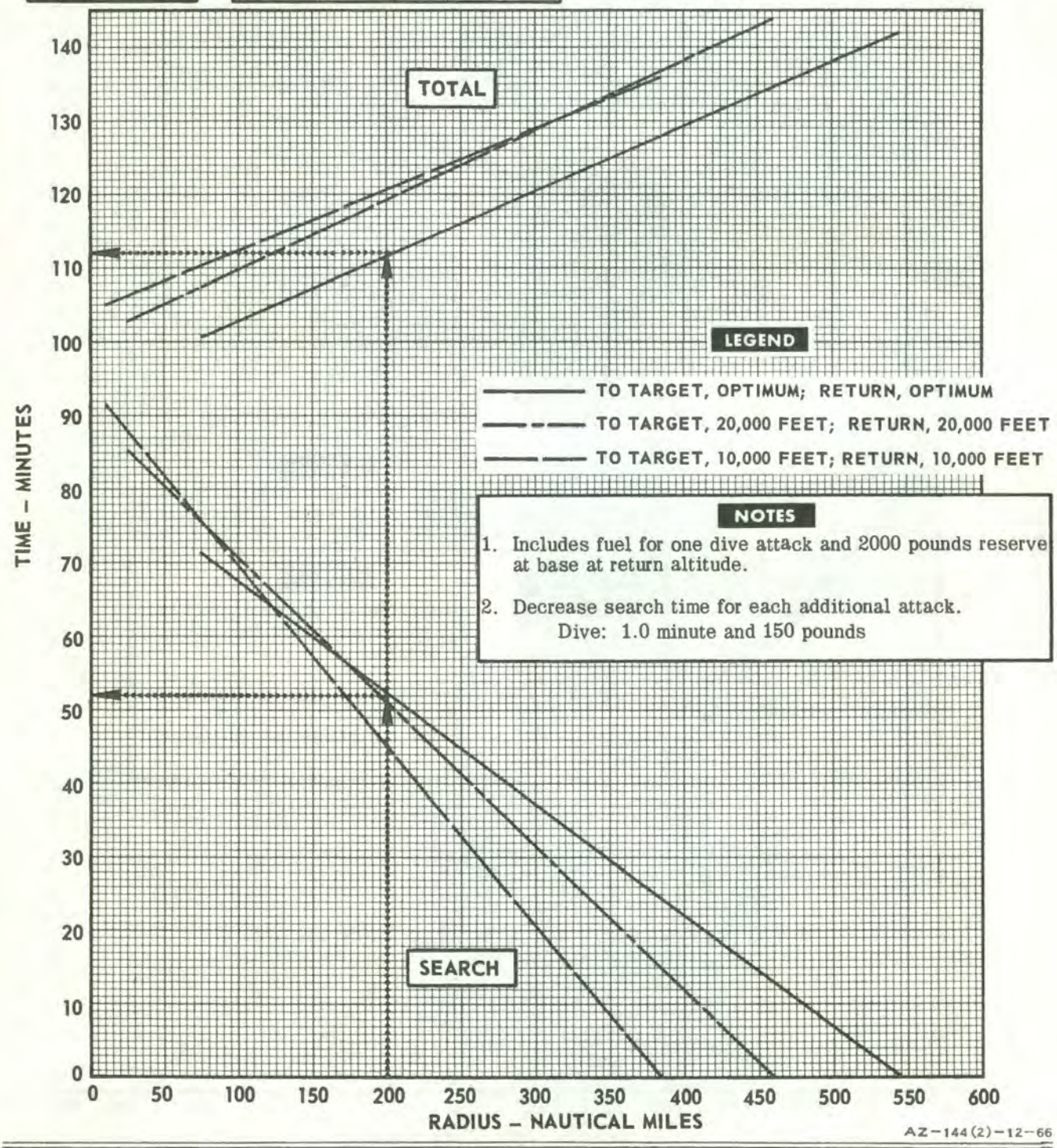


Figure 2–16 (Sheet 2)

Time/Radius Chart

TAKEOFF DRAG INDEX GROSS WEIGHT	
34	29,800 POUNDS

TYPICAL CONFIGURATION	
OUTBOUND	RETURN
(4) AIM – 9C's	(4) AIM – 9C's

CAUTION

This chart is invalid if the return configuration is not as stated for a typical configuration. Extreme deviation from the drag index gross weight combination can also prove this chart invalid.

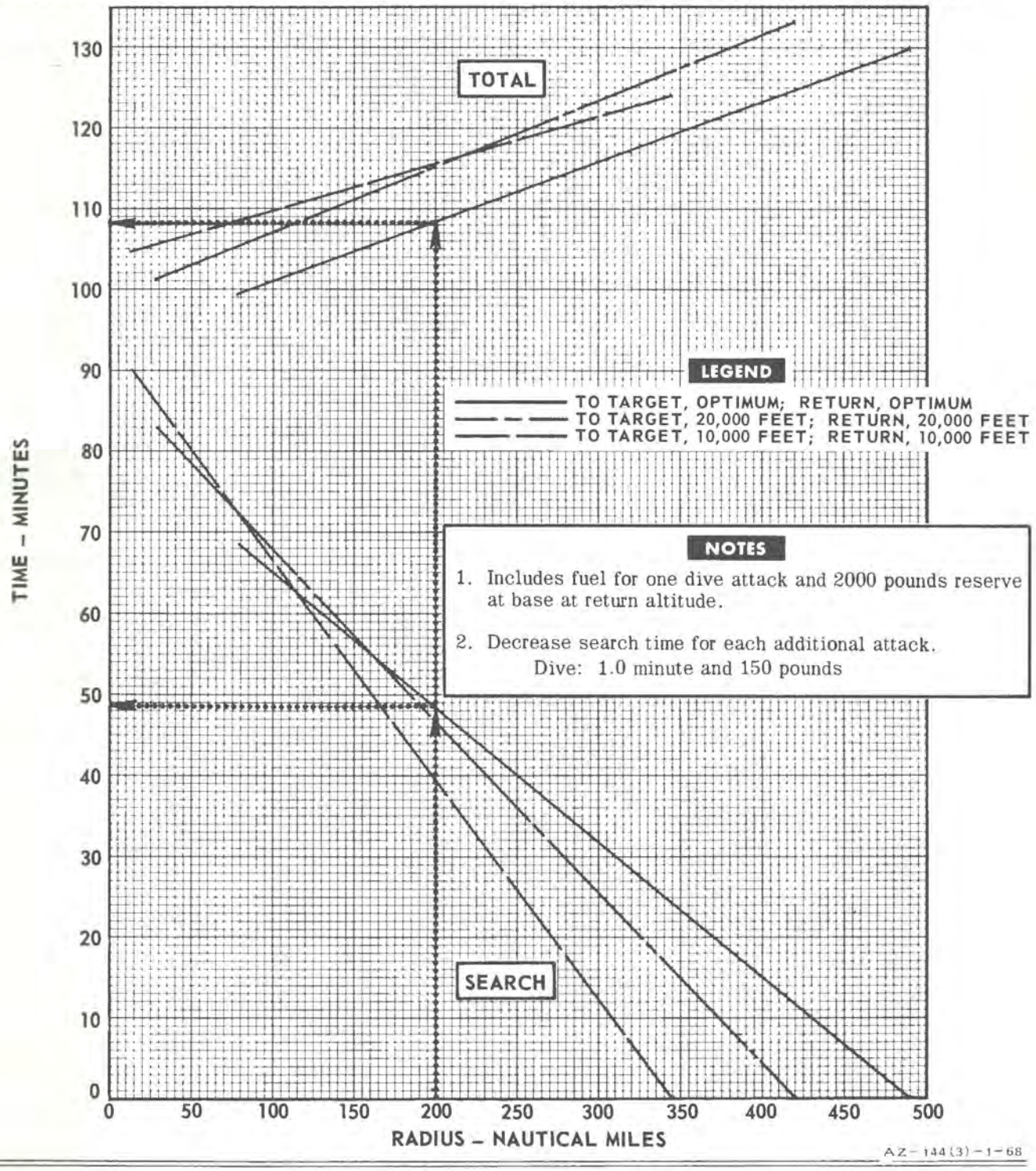


Figure 2–16 (Sheet 3)

Time/Radius Chart

TAKEOFF DRAG INDEX GROSS WEIGHT	
60	30,740 POUNDS

TYPICAL CONFIGURATION	
OUTBOUND	RETURN
(2) MK 82 LD-GP Bombs (2) LAU-33/A's MK 24 Mod 0 Heads	(2) Empty Wing Pylons (2) Empty LAU-33/A's

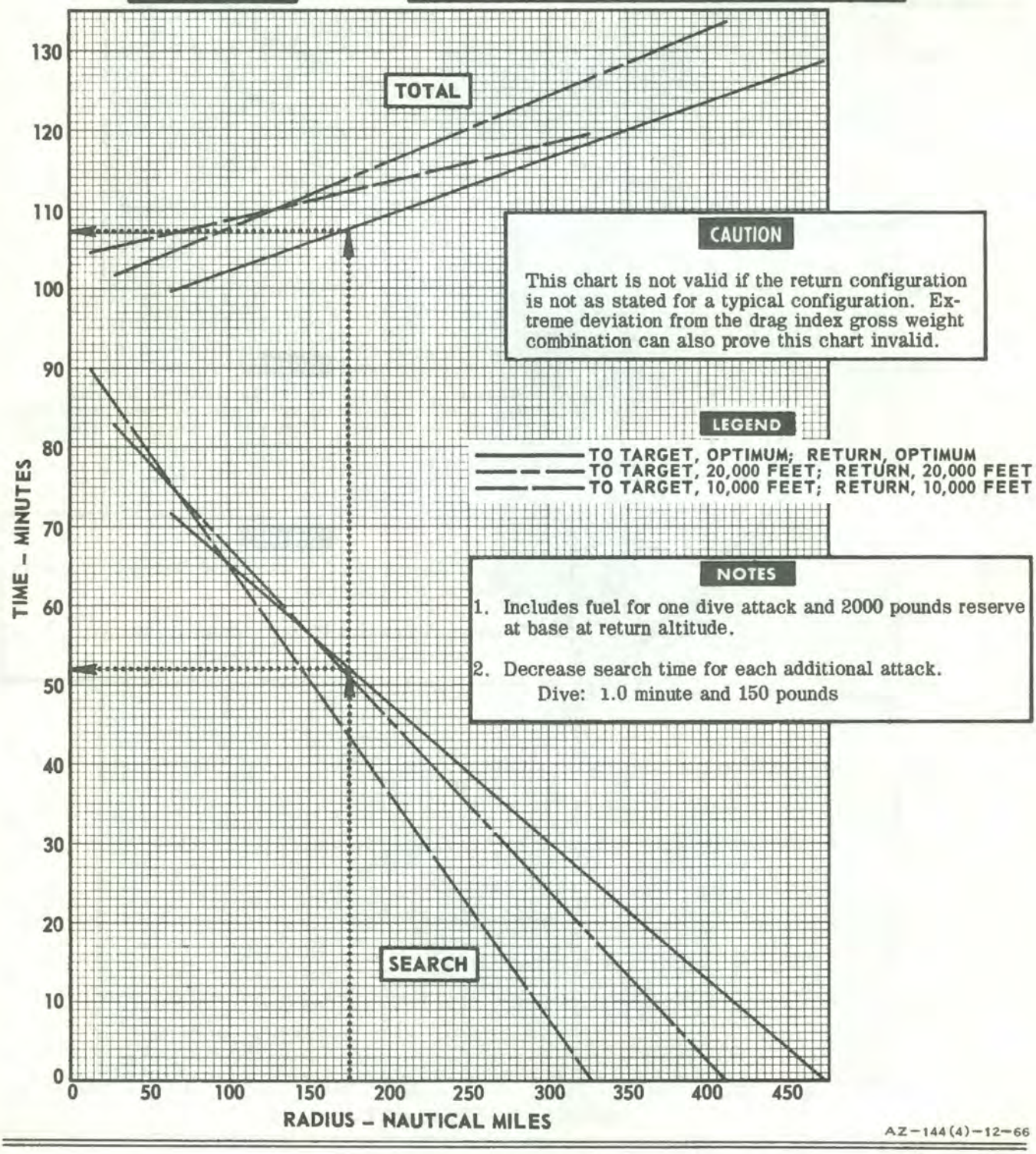


Figure 2–16 (Sheet 4)

Time/Radius Chart

TAKEOFF DRAG INDEX GROSS WEIGHT	
83	31,354 POUNDS

TYPICAL CONFIGURATION	
OUTBOUND	RETURN
(8) MK 81 LD-GP Bombs (2) MBR's or MER's	(2) Empty MBR's or MER's

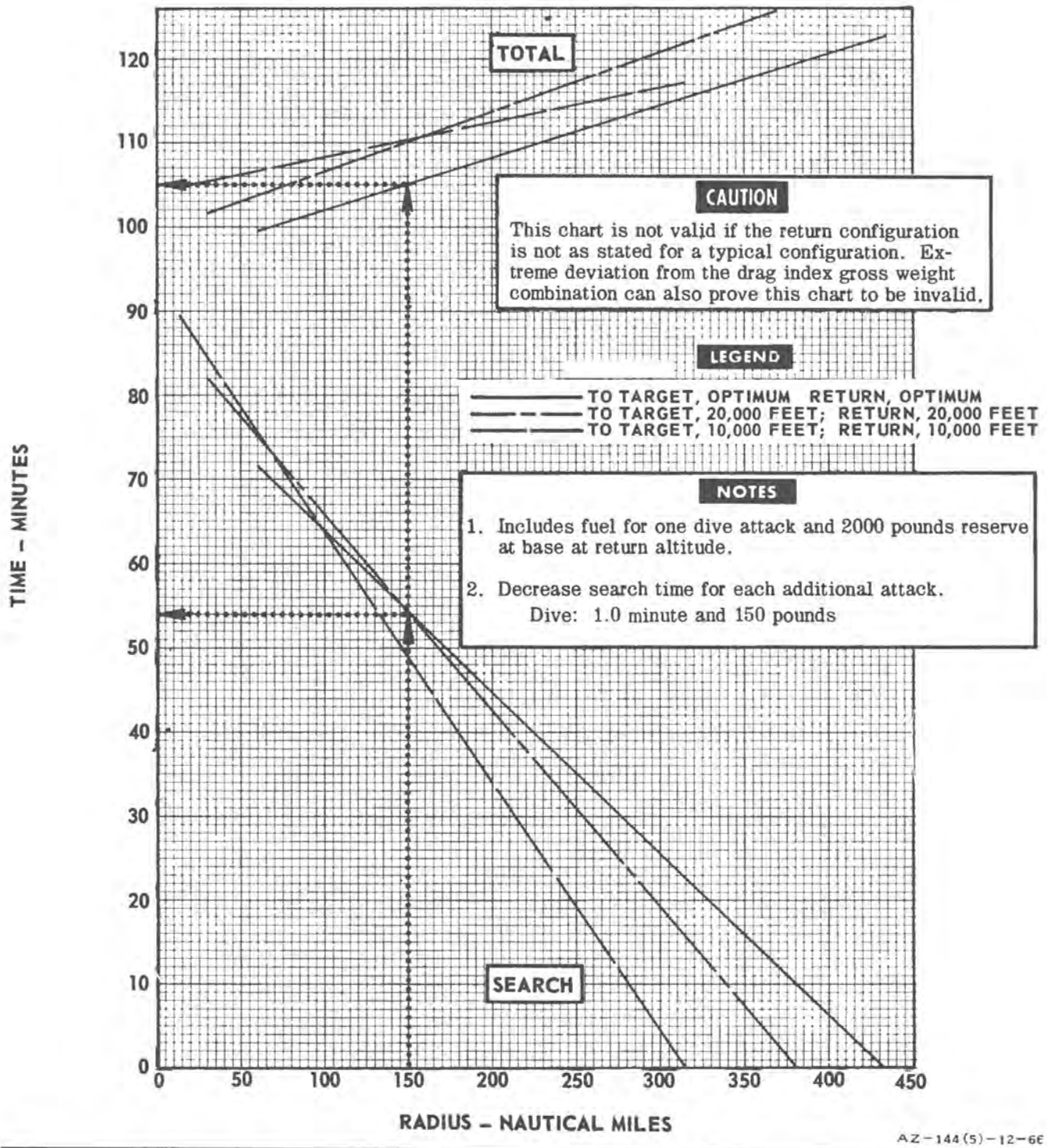


Figure 2–16 (Sheet 5)

Time/Radius Chart

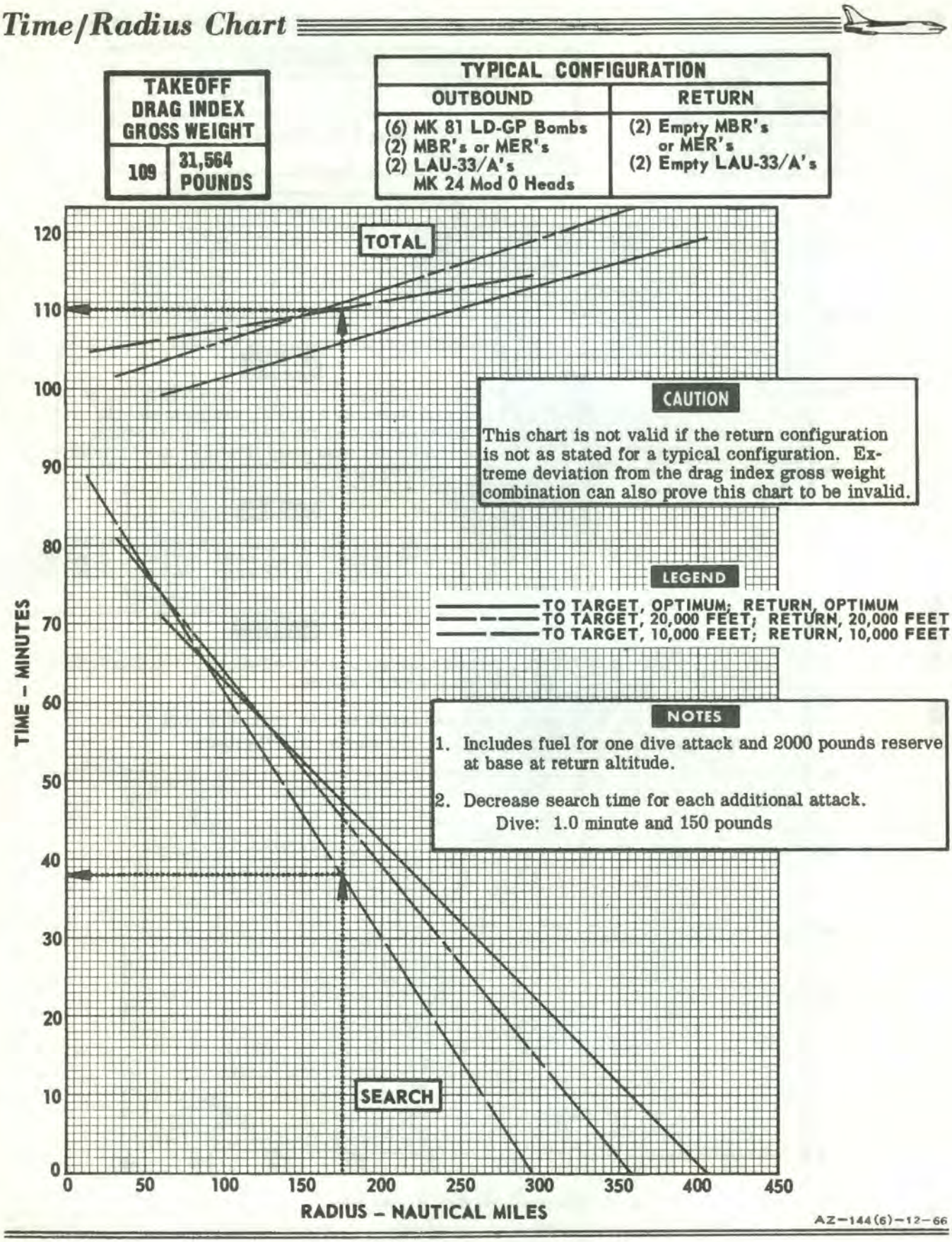


Figure 2–16 (Sheet 6)

Time/Radius Chart

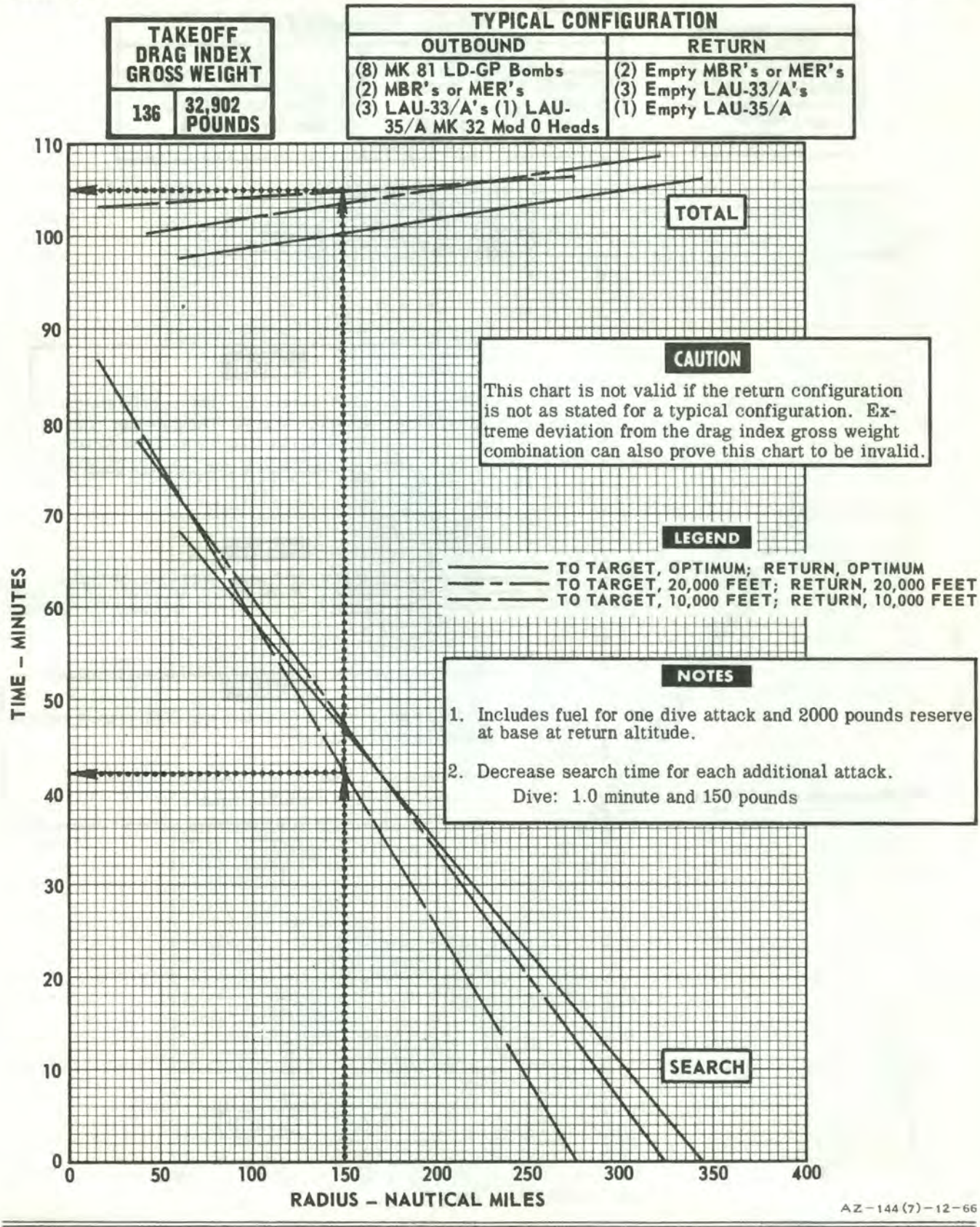


Figure 2–16 (Sheet 7)

Time/Radius Chart

TAKEOFF DRAG INDEX	GROSS WEIGHT
172	34,000 POUNDS

TYPICAL CONFIGURATION	
OUTBOUND	RETURN
(8) MK 82 LD-GP Bombs (2) MBR's or MER's (3) LAU-33/A's (1) LAU-35/A MK 24 Mod 0 Heads	(2) Empty MBR's or MER's (3) Empty LAU-33/A's (1) Empty LAU-35/A

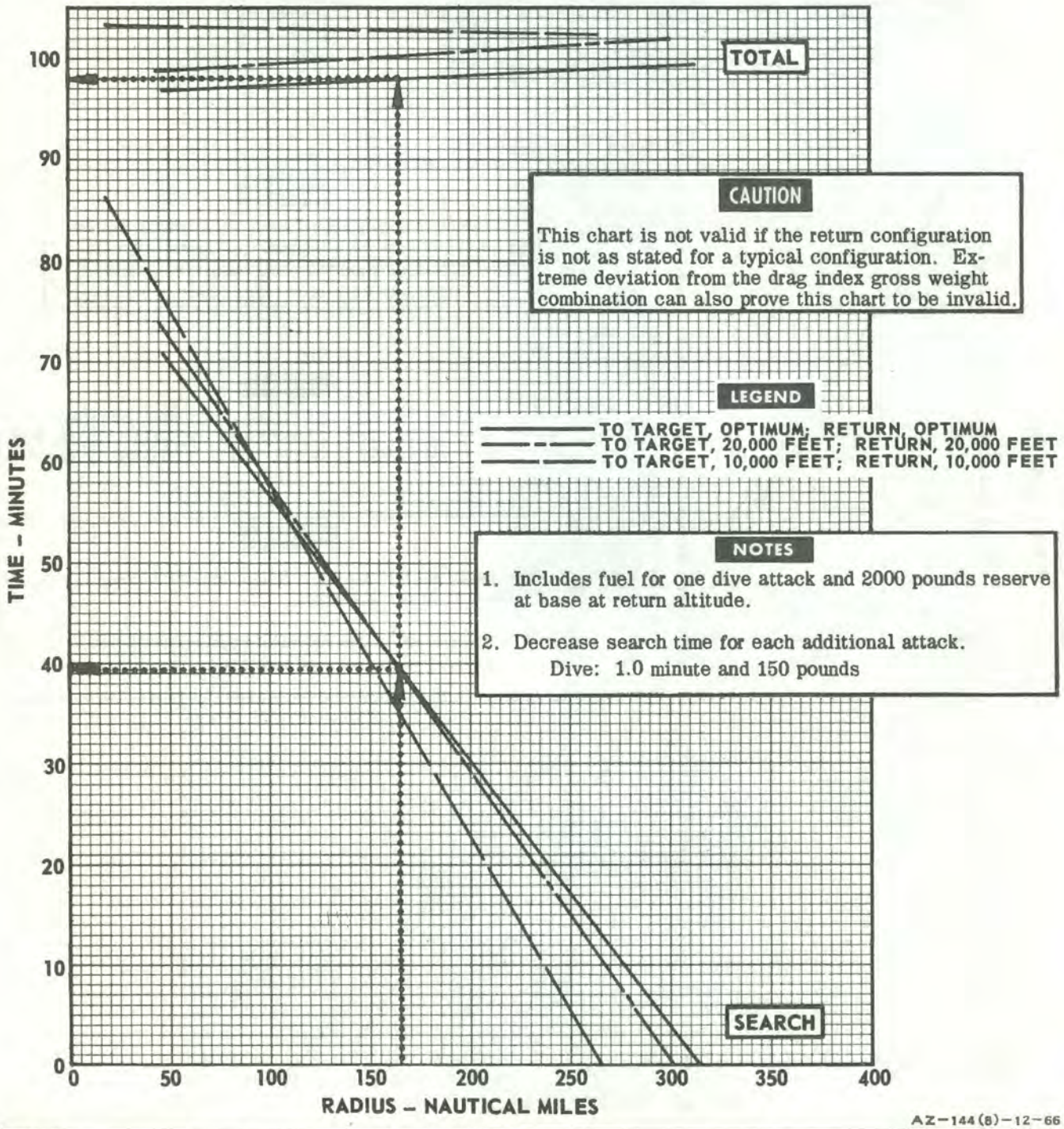


Figure 2–16 (Sheet 8)

Time/Radius Chart



TAKEOFF DRAG INDEX	GROSS WEIGHT
199	34,000 POUNDS

TYPICAL CONFIGURATION	
OUTBOUND	RETURN
(12) MK 81 Snakeye 1 GP Bombs (2) MER's (3) LAU-33/A's (1) LAU-35/A MK 24 Mod 0 Heads	(2) Empty MER's (3) Empty LAU-33/A's (1) Empty LAU-35/A

TOTAL

SEARCH

CAUTION

This chart is not valid if the return configuration is not as stated for a typical configuration. Extreme deviation from the drag index gross weight combination can also prove this chart to be invalid.

LEGEND

——— TO TARGET, OPTIMUM; RETURN, OPTIMUM
— — — TO TARGET, 15,000 FEET; RETURN, 15,000 FEET
——— TO TARGET, 10,000 FEET; RETURN, 10,000 FEET

NOTES

1. Includes fuel for one dive attack and 2000 pounds reserve at base at return altitude.
2. Decrease search time for each additional attack.
   Dive: 1.0 minute and 150 pounds

TIME – MINUTES: 0, 10, 20, 30, 40, 50, 60, 70, 80, 90, 100

RADIUS – NAUTICAL MILES: 0, 50, 100, 150, 200, 250, 300, 350, 400

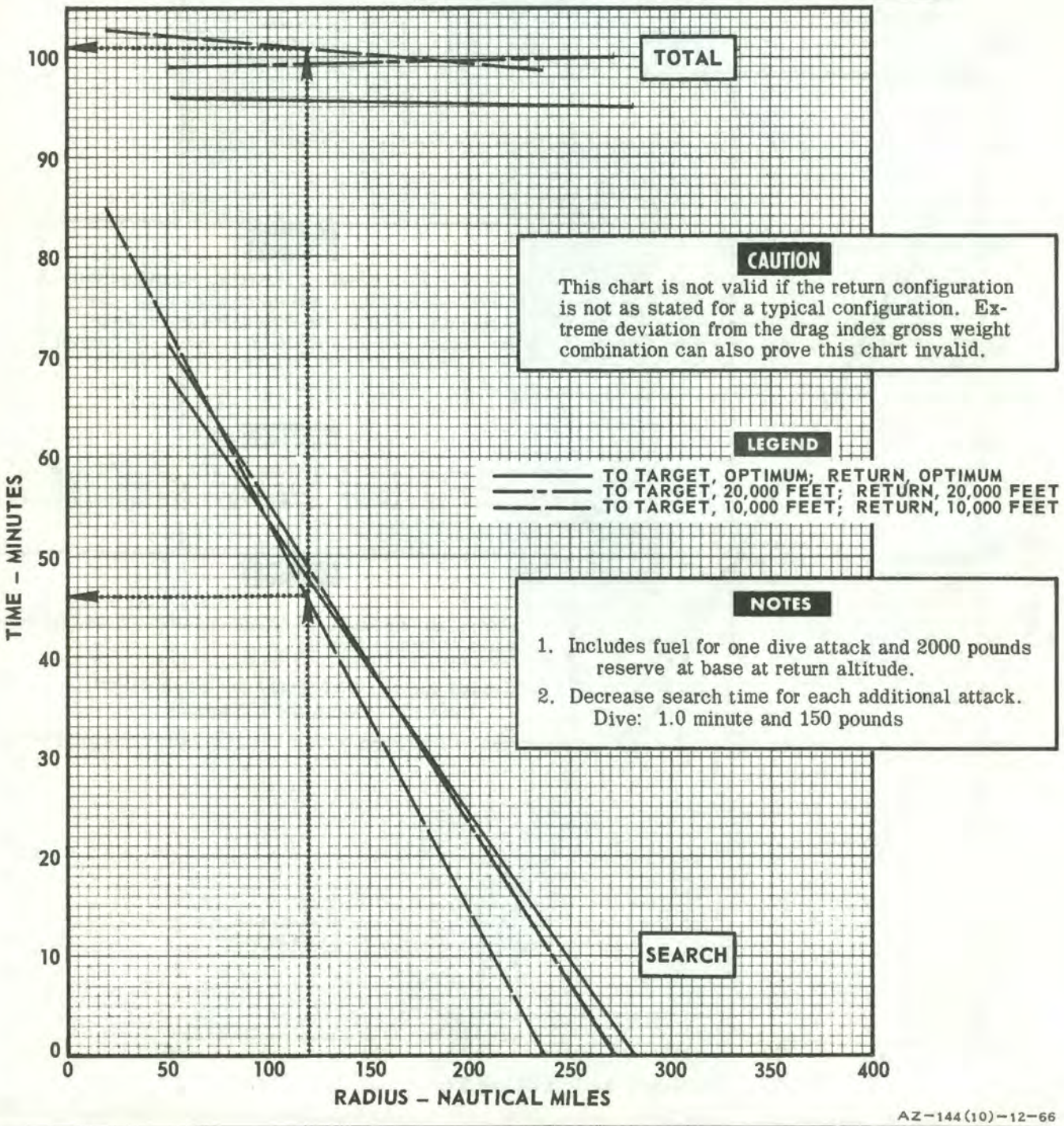
AZ-144(9)-12-66

Figure 2–16 (Sheet 9)

Time/Radius Chart

TAKEOFF DRAG INDEX	GROSS WEIGHT
225	33,100 POUNDS

TYPICAL CONFIGURATION	
OUTBOUND	RETURN
(4) LAU-10/A's Nose and Tail Cones Off MK 32 Mod 0 Heads (2) MER's (3) LAU-33/A's (1) LAU-35/A MK 32 Mod 0 Heads	(4) Empty LAU-10/A's (3) Empty LAU-33/A's (1) Empty LAU-35/A



CAUTION

This chart is not valid if the return configuration is not as stated for a typical configuration. Extreme deviation from the drag index gross weight combination can also prove this chart invalid.

LEGEND

TO TARGET, OPTIMUM; RETURN, OPTIMUM
TO TARGET, 20,000 FEET; RETURN, 20,000 FEET
TO TARGET, 10,000 FEET; RETURN, 10,000 FEET

NOTES

1. Includes fuel for one dive attack and 2000 pounds reserve at base at return altitude.
2. Decrease search time for each additional attack. Dive: 1.0 minute and 150 pounds

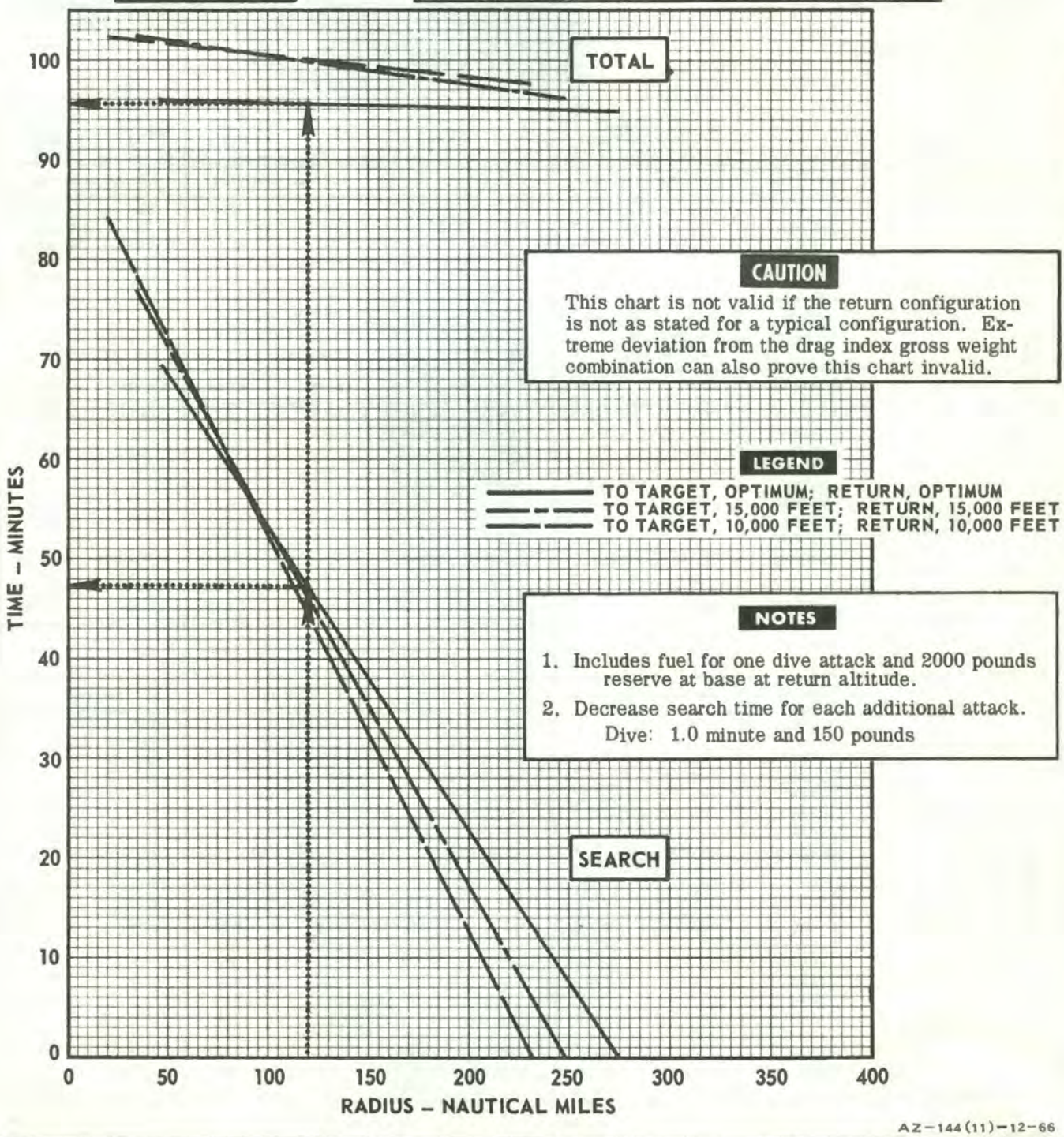
AZ-144(10)-12-66

Figure 2-16 (Sheet 10)

Time/Radius Chart

TAKEOFF DRAG INDEX GROSS WEIGHT	
251	33,100 POUNDS

TYPICAL CONFIGURATION	
OUTBOUND	RETURN
(4) LAU-10/A's Nose and Tail Cones Off MK 24 Mod 0 Heads (2) MER's (3) LAU-33/A's (1) LAU-35/A MK 24 Mod 0 Heads	(4) Empty LAU-10/A's (3) Empty LAU-33/A's (1) Empty LAU-35/A



CAUTION

This chart is not valid if the return configuration is not as stated for a typical configuration. Extreme deviation from the drag index gross weight combination can also prove this chart invalid.

LEGEND

TO TARGET, OPTIMUM; RETURN, OPTIMUM
TO TARGET, 15,000 FEET; RETURN, 15,000 FEET
TO TARGET, 10,000 FEET; RETURN, 10,000 FEET

NOTES

1. Includes fuel for one dive attack and 2000 pounds reserve at base at return altitude.
2. Decrease search time for each additional attack.
   Dive: 1.0 minute and 150 pounds

AZ-144(11)-12-66

Figure 2-16 (Sheet 11)

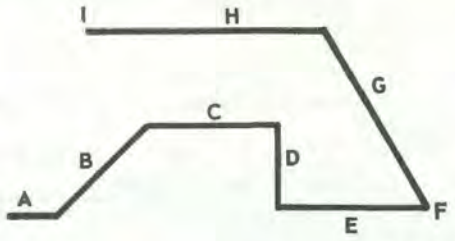
Range Constants

A. Takeoff.
MRT Fuel: 500 Lb
CRT Fuel: 700 Lb

D. Descent: 4500 Ft/Min
Fuel: 14 Lb/Min

F. Dive: 1.0 Min/150 Lb

I. Reserve: 2,000 Lb



CAUTION

This chart is not valid if the return configuration is not as stated for a typical configuration. Extreme deviation from the drag index/gross weight combination can also prove this chart invalid.

TAKEOFF DRAG INDEX / GROSS WEIGHT

LEG			0 / 28,500 POUNDS				15 / 29,100 POUNDS				34 / 29,800 POUNDS				60 / 30,740 POUNDS			
OUTBOUND	B CLIMB	ALTITUDE	LB	NM	MIN	IMN	LB	NM	MIN	IMN	LB	NM	MIN	IMN	LB	NM	MIN	IMN
	MILITARY POWER	5,000	100	5	0.6	0.74	100	5	0.6	0.74	130	6	0.7	0.74	120	6	0.8	0.66
		10,000	200	10	1.3	0.75	220	11	1.4	0.75	250	13	1.6	0.75	270	13	1.8	0.68
		15,000	300	16	2.0	0.77	330	18	2.3	0.77	380	20	2.5	0.77	400	20	2.8	0.69
		20,000	390	22	2.8	0.78	440	25	3.1	0.78	510	29	3.6	0.78	530	28	3.9	0.70
		25,000	490	30	3.7	0.80	550	34	4.3	0.80	640	39	4.9	0.80	680	38	5.3	0.72
		30,000	590	40	5.0	0.82	675	45	5.6	0.82	780	51	6.4	0.82	840	54	7.5	0.73
		35,000	720	53	6.6	0.84	820	60	7.5	0.84	950	69	8.6	0.84	–	–	–	
		OPTIMUM	38,400 Ft Alt				38,300 Ft Alt				36,800 Ft Alt				33,000 Ft Alt			
			830	66	8.3		940	75	9.4		1004	79	9.9		940	63	8.8	
	C CRUISE	ALTITUDE	LB/NM			KTAS	LB/NM			KTAS	LB/NM			KTAS	LB/NM			KTAS
	OPTIMUM CRUISE	SL	11.0			354	11.8			350	12.2			344	13.2			355
		5,000	9.2			362	9.9			360	10.6			356	11.8			358
		10,000	7.9			376	8,5			375	9.4			374	10.4			371
		15,000	7.0			396	7.5			396	8.3			396	9.0			389
		20,000	6.3			420	6.7			420	7.4			420	7.8			413
		25,000	5.7			448	6.2			448	6.7			448	7.2			440
		30,000	5.4			478	5.8			478	6.3			478	6.8			471
		35,000	5.1			498	5.5			498	6.0			498	–			–
		OPTIMUM	38,400 Ft – 40,100 Ft				38,300 Ft – 39,700 Ft				36,800 Ft – 38,200 Ft				33,000 Ft – 34,700 Ft			
			5.0			500	5.4			500	5.9			500	6.7			490
	E SEARCH	ALTITUDE	LB/NM			KTAS	LB/NM			KTAS	LB/NM			KTAS	LB/NM			KTAS
	4,000 LB/HR	SL	11.0			362	11.6			345	11.9			337	13.5			296
RETURN	G CLIMB	ALTITUDE	LB	NM	MIN		LB	NM	MIN		LB	NM	MIN		LB	NM	MIN	
	MILITARY POWER	5,000	80	4	0.5		90	5	0.6		100	5	0.6		100	5	0.6	
		10,000	170	8	1.0		190	10	1.3		220	11	1.4		205	10	1.3	
		15,000	250	13	1.6		280	15	1.9		320	17	2.1		305	15	1.9	
		20,000	320	18	2.2		360	21	2.6		430	25	3.1		405	23	3.0	
		25,000	400	25	3.1		450	28	3.5		530	32	4.0		505	30	3.9	
		30,000	490	32	4.0		550	37	4.6		650	43	5.4		610	40	5.2	
		35,000	580	42	5.3		650	47	5.9		770	56	7.0		720	52	6.7	
		OPTIMUM	41,800 Ft Alt				40,800 Ft Alt				39,100 Ft Alt				38,600 Ft Alt			
			730	61	7.6		810	68	8.5		900	72	9.0		810	67	8.6	
	H CRUISE	ALTITUDE	LB/NM			KTAS	LB/NM			KTAS	LB/NM			KTAS	LB/NM			KTAS
	OPTIMUM CRUISE	SL	10.6			337	11.2			327	11.8			323	11.9			320
		5,000	8.8			343	9.3			338	10.1			336	10.2			332
		10,000	7.5			357	7.9			356	8.8			354	8.8			346
		15,000	6.5			376	7.0			376	7.7			376	7.6			363
		20,000	5.9			400	6.3			400	6.8			400	6.7			386
		25,000	5.3			426	5.7			426	6.2			426	6.0			417
		30,000	4.9			458	5.3			458	5.7			458	5.6			454
		35,000	4.5			490	5.0			490	5.4			490	5.3			474
		OPTIMUM	41,800 Ft – 43,800 Ft				40,800 Ft – 42,400 Ft				39,100 Ft – 40,600 Ft				38,600 Ft – 40,700 Ft			
			4.3			500	4.7			500	5.2			500	5.0			485

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Figure 2-17 (Sheet 1)

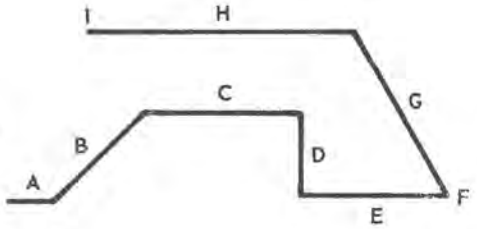
Range Constants

A. Takeoff
MRT Fuel: 500 Lb
CRT Fuel: 700 Lb

D. Descent: 4500 Ft/Min
Fuel: 14 Lb/Min

F. Dive: 1.0 Min/150 Lb

I. Reserve: 2,000 Lb



CAUTION

This chart is not valid if the return configuration is not as stated for a typical configuration. Extreme deviation from the drag index/gross weight combination can also prove this chart invalid.

TAKEOFF DRAG INDEX GROSS WEIGHT

LEG			83 / 31,354 POUNDS				109 / 31,564 POUNDS				136 / 32,902 POUNDS				172 / 34,000 POUNDS			
OUTBOUND	B CLIMB	ALTITUDE	LB	NM	MIN	IMN	LB	NM	MIN	IMN	LB	NM	MIN	IMN	LB	NM	MIN	IMN
	MILITARY POWER	5,000	130	6	0.9	0.63	130	6	0.9	0.61	200	8	1.2	0.60	220	8	1.3	0.57
		10,000	300	14	2.1	0.64	310	14	2.1	0.62	380	16	2.5	0.61	430	18	2.9	0.58
		15,000	440	22	3.2	0.65	480	22	3.3	0.64	540	25	3.9	0.62	660	28	4.5	0.59
		20,000	590	30	4.4	0.66	620	32	4.8	0.65	730	38	5.9	0.63	920	44	7.1	0.61
		25,000	750	43	6.3	0.68	810	46	6.9	0.66	990	55	8.5	0.65	–	–	–	–
		30,000	950	60	8.9	0.69	–	–	–	–	–	–	–	–	–	–	–	–
		35,000	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
		OPTIMUM	30,000 Ft Alt				29,300 Ft Alt				26,000 Ft Alt				22,200 Ft Alt			
			950	60		8.9	980	60		9.0	1070	60		9.3	990	47		7.6
	C CRUISE	ALTITUDE	LB/NM			KTAS	LB/NM			KTAS	LB/NM			KTAS	LB/NM			KTAS
		SL	14.0			342	14.7			329	15.6			324	16.7			319
		5,000	12.5			345	13.1			333	13.8			330	14.8			328
		10,000	11.0			358	11.7			344	12.4			342	13.3			341
		15,000	9.6			376	10.4			362	11.2			360	12.2			359
		20,000	8.7			405	9.4			387	10.2			385	11.3			385
	OPTIMUM CRUISE	25,000	8.1			435	8.6			417	9.4			415	–			–
		30,000	7.7			465	–			–	–			–	–			–
		35,000	–			–	–			–	–			–	–			–
		OPTIMUM	30,000 Ft – 31,900 Ft				29,300 Ft – 31,200 Ft				26,000 Ft – 28,100 Ft				22,200 Ft – 24,600 Ft			
			7.7			465	8.0			456	9.2			420	10.9			405
	E SEARCH	ALTITUDE	LB/NM			KTAS	LB/NM			KTAS	LB/NM			KTAS	LB/NM			KTAS
	4,000 LB/HR	SL	14.2			281	14.6			271	15.7			255	17.0			235
RETURN	G CLIMB	ALTITUDE	LB	NM	MIN		LB	NM	MIN		LB	NM	MIN		LB	NM	MIN	
	MILITARY POWER	5,000	100	5	0.6		100	4	0.6		120	5	0.7		120	5	0.7	
		10,000	205	10	1.3		210	10	1.4		240	11	1.6		240	11	1.6	
		15,000	305	15	1.9		310	15	2.1		380	17	2.5		380	17	2.5	
		20,000	405	23	3.0		410	22	3.1		490	24	3.5		490	24	3.5	
		25,000	505	30	3.9		510	30	4.2		600	33	4.9		600	33	4.9	
		30,000	610	40	5.3		620	40	5.6		720	44	6.5		720	44	6.5	
		35,000	720	52	6.9		730	52	7.2		890	60	8.9		890	60	8.9	
		OPTIMUM	38,400 Ft Alt				37,000 Ft Alt				35,000 Ft Alt				35,000 Ft Alt			
			808	66		8.7	800	60		8.4	890	60		8.9	890	60		8.9
	H CRUISE	ALTITUDE	LB/NM			KTAS	LB/NM			KTAS	LB/NM			KTAS	LB/NM			KTAS
		SL	12.0			317	12.7			310	13.4			318	13.4			318
		5,000	10.4			328	11.0			320	11.6			331	11.6			331
		10,000	9.0			343	9.5			335	10.1			348	10.1			348
		15,000	7.8			361	8.2			353	8.9			372	8.9			372
		20,000	6.8			384	7.2			376	8.0			407	8.0			407
	OPTIMUM CRUISE	25,000	6.1			414	6.4			407	7.4			437	7.4			437
		30,000	5.7			450	5.9			438	7.0			457	7.0			457
		35,000	5.4			470	5.7			456	–			–	–			–
		OPTIMUM	38,400 Ft – 40,300 Ft				37,000 Ft – 38,700 Ft				35,000 Ft – 36,800 Ft				35,000 Ft			36,800 Ft
			5.1			480	5.6			463	6.8			470	6.8			470

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Figure 2-17 (Sheet 2)

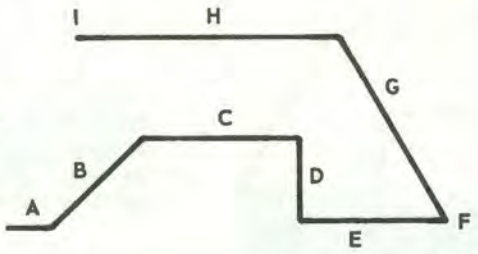
Range Constants

A. Takeoff
MRT Fuel: 500 Lb
CRT Fuel: 700 Lb

D. Descent: 4500 Ft/Min
Fuel: 14 Lb/Min

F. Dive: 1.0 Min/150 Lb

I. Reserve: 2,000 Lb



CAUTION

This chart is not valid if the return configuration is not as stated for a typical configuration. Extreme deviation from the drag index/gross weight combination can also prove this chart invalid.

TAKEOFF DRAG INDEX / GROSS WEIGHT

LEG			199 / 34,000 POUNDS				225 / 33,100 POUNDS				251 / 33,100 POUNDS				/			
OUTBOUND	B CLIMB	ALTITUDE	LB	NM	MIN	IMN	LB	NM	MIN	IMN	LB	NM	MIN	IMN	LB	NM	MIN	IMN
		5,000	240	9	1.5	0.56	240	9	1.5	0.55	260	9	1.6	0.53				
		10,000	470	19	3.1	0.57	470	19	3.2	0.56	520	20	3.5	0.54				
		15,000	740	32	5.3	0.58	740	32	5.4	0.57	800	34	5.9	0.55				
		20,000	–	–	–		1007	50	8.5	0.58	–	–	–					
	MILITARY POWER	25,000	–	–	–		–	–	–		–	–	–					
		30,000	–	–	–		–	–	–		–	–	–					
		35,000	–	–	–		–	–	–		–	–	–					
		OPTIMUM	19,700 Ft Alt				20,400 Ft Alt				18,700 Ft Alt							
			1020	48	8.0		1110	52	8.8		1040	47	8.2					
	C CRUISE	ALTITUDE	LB/NM		KTAS		LB/NM		KTAS		LB/NM		KTAS		LB/NM		KTAS	
		SL	18.5		311		19.0		314		19.6		304					
		5,000	16.0		320		16.6		325		17.2		315					
		10,000	14.4		333		15.0		337		15.5		329					
		15,000	13.1		351		13.8		357		14.2		348					
		20,000	–		–		12.5		381		–		–					
	OPTIMUM CRUISE	25,000	–		–		–		–		–		–					
		30,000	–		–		–		–		–		–					
		35,000	–		–		–		–		–		–					
		OPTIMUM	19,700 Ft – 22,900 Ft				20,400 Ft – 23,200 Ft				18,700 Ft – 21,700 Ft							
			12.0		373		12.3		393		12.9		373					
	E SEARCH	ALTITUDE	LB/NM		KTAS		LB/NM		KTAS		LB/NM		KTAS		LB/NM		KTAS	
	4,000 LB/HR	SL	18.3		218		19.0		211		20.0		200					
RETURN	G CLIMB	ALTITUDE	LB	NM	MIN		LB	NM	MIN		LB	NM	MIN		LB	NM	MIN	
		5,000	120	5	0.7		140	6	0.9		140	6	0.9					
		10,000	240	11	1.6		280	12	1.9		280	12	1.9					
		15,000	380	17	2.5		410	19	2.9		410	19	2.9					
		20,000	490	24	3.5		540	27	4.2		540	27	4.2					
	MILITARY POWER	25,000	600	33	4.9		690	36	5.6		690	36	5.6					
		30,000	720	44	6.5		850	51	7.9		850	51	7.9					
		35,000	890	60	8.9		–	–	–		–	–	–					
		OPTIMUM	35,000 Ft Alt				32,400 Ft Alt				32,400 Ft Alt							
			890	60	8.9		940	59	9.1		940	59	9.1					
	H CRUISE	ALTITUDE	LB/NM		KTAS		LB/NM		KTAS		LB/NM		KTAS		LB/NM		KTAS	
		SL	13.4		318		14.5		292		14.5		292					
		5,000	11.6		331		12.6		295		12.6		295					
		10,000	10.1		348		11.1		308		11.1		308					
		15,000	8.9		372		9.9		329		9.9		329					
		20,000	8.0		407		8.9		357		8.9		357					
	OPTIMUM CRUISE	25,000	7.4		437		8.1		390		8.1		390					
		30,000	7.0		457		7.5		419		7.5		419					
		35,000	–		–		–		–		–		–					
		OPTIMUM	35,000 Ft – 36,800 Ft				32,400 Ft – 34,300 Ft				32,400 Ft – 34,300 Ft							
			6.8		470		7.3		433		7.3		433					

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Figure 2-17 (Sheet 3)

ASSUMPTIONS

The following assumptions are in addition to those listed in the cruise control charts.

a. ICAO standard atmosphere

b. No wind

c. No base movement during mission

d. No fuel allowance for rendezvous

e. Time allowance for engine start, taxi, and take-off is 10 minutes

f. Clean aircraft weight (less pilot, fuel and stores) — 18,800 pounds

g. Full fuel load (JP-5) — 9,167 pounds

h. Pilot — 180 pounds

i. 20MM ammunition (500 rds) — 355 pounds

DRAG INDEX TABLE

The cruise control data are presented in accordance with the drag index system. Drag index is the sum of the drag numbers obtained from figure 2–14 and represents the true drag for the specific configuration.

CLIMB SCHEDULE CHART

The climb schedule chart (figure 2–15) provides the optimum climb speed for each altitude (5,000-foot increments) for the drag indexes listed.

TIME/RADIUS CHARTS

The time/radius charts (figure 2–16) provide the search time available in the target area at a specific range. Total mission time can also be determined. The drag indexes and altitudes listed must be closely adhered to, in order to ensure accuracy. For optimum cruise altitude, refer to the range constants tables (figure 2–17).

RANGE CONSTANTS TABLES

The range constants tables (figure 2–17) present the data necessary to compute mission fuel, time, and distance. The information is listed by drag index number. Deviations from the drag indexes listed must be interpolated in the computations.

SAMPLE PROBLEM

Known facts are:

a. Configuration outbound: Six Mk 81 Snakeye I GP bombs and two TER's

b. Distance to target: 185 nautical miles

c. Configuration return: Two TER's

Computations: (See Cruise Assumptions)

From Drag Index Table (Figure 2–14):

	Weight	*Drag*
Clean aircraft (less pilot, fuel, and stores)	18,800	0
Fuel	9,167	0
Pilot	180	0
20mm ammunition	355	0
(6) Mk 81 Snakeye I GP Bombs	1,806	39.0
(2) Wing pylons, AERO 7A-1 EBR and TER	664	41.0
TOTALS	30,972	80.0

From Time/Radius Chart (figure 2–16, sheet 5):

Search Time	48 min
Total mission time	107 min

From Range Constants Chart (figure 2–17, sheet 3):

Initial optimum cruise altitude, outbound — 30,000 feet
return — 38,400 feet

Fuel specifics — see variables on chart

From Climb Schedule Table (figure 2–15):

Recommended climb speed 407 KTAS

PART 2 — MISSIONS

GENERAL

One or a combination of the following attack missions may be assigned: Prebriefed Strike, Armed Reconnaissance, Close Air Support, and Radar Controlled Bombing. The flight may consist of any number of aircraft, depending on the importance of the mission or the amount of ordnance necessary to achieve the desired results, and may or may not require fighter escort. Factors common to all attack missions are presented in the following paragraphs.

INTELLIGENCE

An integral part of any mission is the reliable and timely acquisition of intelligence information which may include the following:

a. Direction and movement of forces and weapons into or within the area.

b. Location, arrangement and employment of enemy weapons.

c. Disposition of enemy ground forces.

d. Concentration and build-up of strategic reserves.

e. Total apparent enemy strength.

f. Conditions of communications and their capacity.

g. Good choke points such as bridges and passes.

h. Weather conditions.

NIGHT/LOW VISIBILITY CONSIDERATIONS

A mission at night or in low visibility requires that consideration be given to the following:

a. Rendezvous position for the strike force.

b. Enroute formation.

c. Precise navigation planning, utilizing DR as backup for external navigation aids.

d. Minimum altitudes above the highest terrain within 15 miles of the planned route.

CAMOUFLAGE

Enemy camouflage will vary according to tactical need and cleverness. The absence of activity or targets can indicate that the enemy is concealed. Diligent searching and careful scrutiny will often reveal evidence of concealed enemy activity, such as tire tracks, cut away brush and flashes of reflected sunlight. If intensive enemy fire is encountered, it could be assumed that the enemy is defending something of importance. Caution should be exercised if attempting to determine the location of the defended target. Be aware of possible flak traps such as isolated vehicles parked along a road.

PREBRIEFED STRIKES

A mission planned before launch to strike a specific target, such as a bridge, dam, or powerplant, is defined as a prebriefed strike. The flight proceeds to the target, attacks, and returns to the ship or base. A prebriefed strike may be assigned more than one target, but it does not involve searching for possible targets not previously briefed. When several aircraft are involved, the problem of delivering ordnance accurately while diving in a multiplane attack is more difficult than working individually. Tactics for prebriefed strikes must be flexible to take advantage of unforeseen opportunities which may improve the success of the mission. Weapons delivery in sections where the wingman flies a tight, forward tactical wing and releases on cue from the leader can be utilized. A low altitude run-in and retirement may reduce the possibility of radar detection and provides some element of surprise. However, heavily defended routes or target areas should not be crossed at low altitudes unless surprise is assured or unless the SAM threat is extremely high. The proper pop-up techniques are discussed in Part 3 of this section. The pop-up and roll-in interval should be briefed.

FAN GLIDE (WAGON WHEEL)

Attacks by individual aircraft within a flight should be made with as much dive heading difference as interval and defenses will permit. Flight patterns viewed from above will look like "wagon wheel" spokes with the target as the hub.

SECTION GLIDE

This is a low approach and pop-up attack performed in section.

ARMED RECONNAISSANCE

Armed reconnaissance is a pre-planned mission. Its primary purpose is to search out, attack, and destroy targets of opportunity along a designated route or within an assigned area. Armed reconnaissance will normally be accomplished by one or two sections of aircraft. If air supremacy has not been attained, it may be necessary to employ one section as top cover. Sufficient capability (airspeed, ordnance and fuel) for defensive purposes should be retained at all times. Airspeed, altitudes, and tactical maneuvering during armed reconnaissance missions will be influenced by

aircraft configuration and enemy defenses. However, altitudes above 6,000 feet AGL will preclude detailed reconnaissance. In planning for armed reconnaissance missions, several bingo points should be preselected. A good rule of thumb for estimating enroute time and fuel is to multiply the length of the route by a factor of 1.3.

Section tactics and formation positions should be determined according to anticipated enemy air action, number of aircraft employed, intensity and capability of enemy ground weapons, type of terrain to be reconnoitered, and the configuration and armament load of the fighter reconnaissance aircraft. Formations should scissor and vary altitude along the route, especially when ground defenses are active.

When a single section is employed, the wingman may follow at a prescribed interval. He should stay offset at a slightly higher altitude, avoid the in-trail position and never cross the route at the same point as the lead aircraft. These same considerations apply for reconnaissance of general areas, except that parallel tracks may be used instead of route following. Mission effectiveness increases considerably when pilots are thoroughly familiar with the routes and areas to be reconnoitered.

The leap-frog tactic is an effective and easily performed maneuver for armed reconnaissance missions. The second element attacks a target called out by the first. During the run into the target, the first aircraft goes high and off to the side to observe the attack and to call flak. The second element pulls off the target and resumes the base reconnoiter course, thus becoming lead. The former lead element maneuvers to assume position on the new lead.

Munitions should be expended conservatively to achieve the desired degree of destruction. In all instances the second attacker must ensure proper interval and that the first attacker is clear before delivering any ordnance. If a reattack is executed, be alert for flak.

Pilots will not always be able to achieve preplanned release conditions. A high degree of skill in weapons delivery is mandatory. A pilot must possess the ability to deliver weapons from any dive angle, and within a wide range of airspeeds. He must be capable of continually analyzing the delivery maneuver and be highly proficient in "that looks about right" weapons delivery. This skill can be gained only through practical experience, provided a pilot first has a good knowledge of error analysis. Being able to deliver ordnance from any position relative to the target will permit the accurate delivery of weapons on the first attack and increases the chances of survival against heavily defended targets. Remember, the enemy will probably increase defenses along critical or frequently reconnoitered routes.

Previously mentioned night considerations and those in Part 3 of this section apply to armed reconnaissance missions. Additional factors are:

a. Formation integrity can be maintained by making maximum use of AI radar, UHF radio, Air-to-Air TACAN and ADF when feasible.

b. Normally the lead aircraft will be the hunter (flare aircraft) and the wingman the "Killer" (ordnance aircraft.

CLOSE AIR SUPPORT

The close air support mission involves an attack under the control of a ground or airborne FAC (Forward Air Controller). A specific target may be pre-briefed or assigned when airborne. Upon reporting, inform the FAC of the flight call sign, mission number, number and type of aircraft, ordnance on each aircraft, and time on station. The flight should receive the location, description and elevation of the target, surface wind, location of nearby friendlies, and desired and restricted delivery headings. No attacks should be commenced without positive radio contact and target confirmation from the controlling FAC.

If anti-aircraft fire is not a factor, any attack pattern compatible with existing weather and FAC information can be used. If weather at the target precludes attack, the FAC may assign another target. While holding, or after new target assignment, advise the FAC of updated time on station.

The FAC should give a BDA (bomb damage assessment) report after the attack as the flight departs.

GROUND RADAR CONTROLLED BOMBING

A ground radar controlled bombing mission uses ground-based radar to vector aircraft to a preselected bomb release point. This type of bombing is suitable against area targets such as airfields, petroleum storage, railroad yards and waterfronts during darkness or adverse weather.

Pilot technique involves flying a constant airspeed, altitude and heading as directed. The relatively long, straight, level delivery makes the aircraft extremely vulnerable.

PART 3 — ATTACK

The F-8 has the capability of conventional weapons delivery against ground targets. Two wing-mounted pylons provide suspension for carriage of single weapons or for carriage of the MER, TER or MBR. Specific information regarding weapon compatibility and limitations is contained in Part 1 of this section.

DIVE DELIVERY

The dive attack which can encompass dive angles of 10 to 60 degrees, is particularly well suited for delivery of free-fall and retarded bombs, rockets and 20MM ammunition. The attack will be discussed in the following sequence: entry, tracking (to include release), and recovery. See figure 2–18.

ENTRY

The desired roll-in point can be attained by one of several entry maneuvers, e.g., the pop-up entry maneuver, the level entry, and the high entry. The entry maneuver must enable the pilot to position the aircraft on the desired dive path at a distance from the release point that allows adequate time to make the minor corrections required to achieve the planned release conditions.

A pilot in a combat situation does not have the advantage of familiar landmarks to help him determine the roll-in point for a specific dive angle. He must select the proper roll-in point based upon altitude and estimated range to the target. Each pilot may have a slightly different method for determining this position, but all methods should result in achieving preselected release conditions for the weapon to be delivered.

Dive Delivery

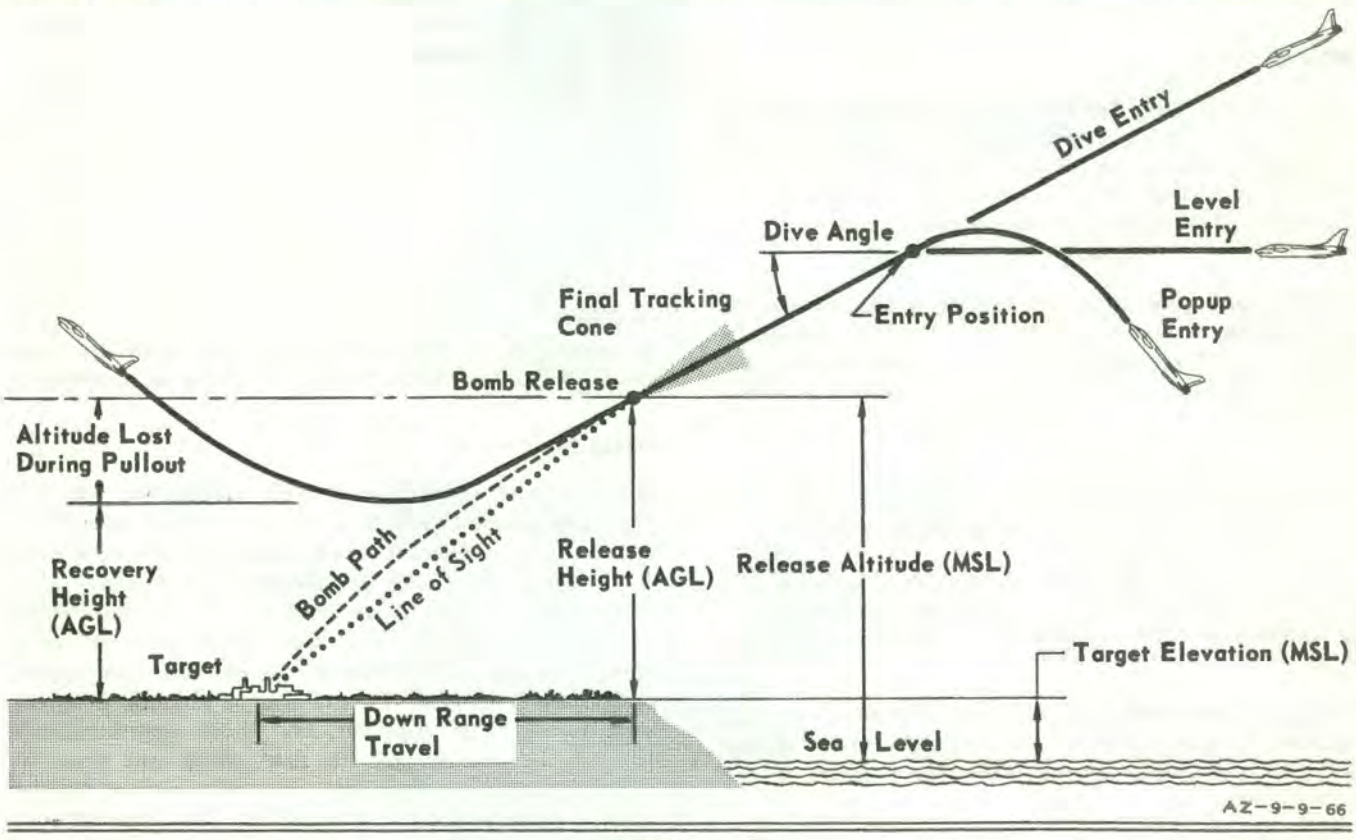


Figure 2–18

Pop-up

A pop-up (or pitch-up) is defined as a rapid climb from low altitude to a point where the aircraft is maneuvered into position for a specific weapons delivery. It may provide an element of surprise and reduce exposure time to heavy enemy ground defenses in the immediate target area.

Roll Ahead

When the final attack heading is within 30 degrees of the approach heading to the target, a roll-ahead pop-up is recommended (figure 2–19). The pull-up point is located twice the horizontal distance from the planned roll-in point to the target. During the approach to the pull-up point, an acceleration to the planned release airspeed is accomplished. At the pull-up point, a climb angle that is equal to the planned dive angle, is established on the VGI. The climb path should be slightly left or right of the target to enhance target acquisition during the climb. Approximately 1,500 feet below the planned entry altitude, the aircraft is rolled inverted and the climb continued. When the desired roll-in position is reached, the nose of the aircraft is pulled through the horizon and the gunsight pipper is placed near the target. G is relaxed, the aircraft rolled wings level and tracking begun.

Off-Set

If the final attack heading will be greater than 30 degrees from the approach heading, an offset pop-up is recommended (figure 2–20). The pull-up point will be less than twice the horizontal distance from the planned roll-in point to the target. Techniques described for the roll-ahead pop-up will apply.

When planning an attack using a low-angle dive and a low release or firing altitude, the maneuver shown in figure 2–21 is recommended. This maneuver is particularly adaptable to strafing and for retarded bombing attacks.

When higher release altitudes are desired, an increased off-set angle and steeper dive will combine to give the minimum exposure time (figures 2–22 and 2–23).

If the pilot misses the pull-up point or is too near the target to accomplish his planned pop-up maneuver, an unplanned off-set pop-up is recommended (figure 2–24).

If the target is missed and the unplanned off-set pop-up maneuver is not desirable, the reversal pop-up (figure 2–25) or the repositioning maneuver (figure 2–26) can be used.

Level Entry

When approaching the roll-in point, climb or descend to the predetermined entry altitude and establish the proper roll-in airspeed. The entry airspeed will vary with roll-in altitude and configuration. Higher speeds are desirable when attacking heavily defended targets.

The roll-in technique may be varied to meet desired release conditions. If the roll-in position appears to be too far out, a level turn should be made toward the target to intercept the desired dive angle. If the position appears to be too close to the target, an immediate nose-low roll-in will help to prevent the dive from becoming too steep. Engine power can be adjusted for a short interval to compensate for variations in roll-ins. A correct roll-in will place the aircraft in a dive about 5 degrees steeper than planned with the mil lead point short of the target. This technique will allow the pilot to devote most of his time and attention to tracking and to airspeed and altitude control.

High Entry

The high entry is used when the altitude is greater than that planned for the level or pop-entry. The descent must be carefully controlled to reach a preplanned airspeed, altitude and position.

TRACKING

To counteract the shallowing effect of a headwind, the roll-in point should be moved closer to the target. For tail-wind compensation, the opposite correction is necessary. When on the desired dive angle, the pipper is placed near the target and the wings rolled level to align the mil lead point with the aim point. This will reduce pendulum effect. After the dive is established, coordinated flight is required. An immediate correction at this time will compensate for small errors in the dive angle and will still allow sufficient time for tracking. As the dive progresses, the mil lead point is allowed to drift up to the aim point. The drift rate is controlled to allow the mil lead point to pass through the aim point at the desired release conditions.

RELEASE

Before commencing the delivery maneuver, the aircraft should be trimmed for the planned release airspeed. The pilot should concentrate on the target and the sight picture using peripheral vision to check altitude, airspeed, and trim (ball centered). Normally, one check of airspeed should be made about halfway down the dive and correction made with an appropriate power change. Two checks of altitude progress will normally be sufficient, one check approximately half way to release and the final check just prior to release. Altitude loss during the latter portion of the dive is approximately 400 to 500 feet per second. Therefore, leading the altimeter by about 500 feet will permit one second of final concentrated tracking time to ensure that the mil lead point is on the aim point and the aircraft attitude is stabilized at release.

Roll-ahead Pop-up Maneuver

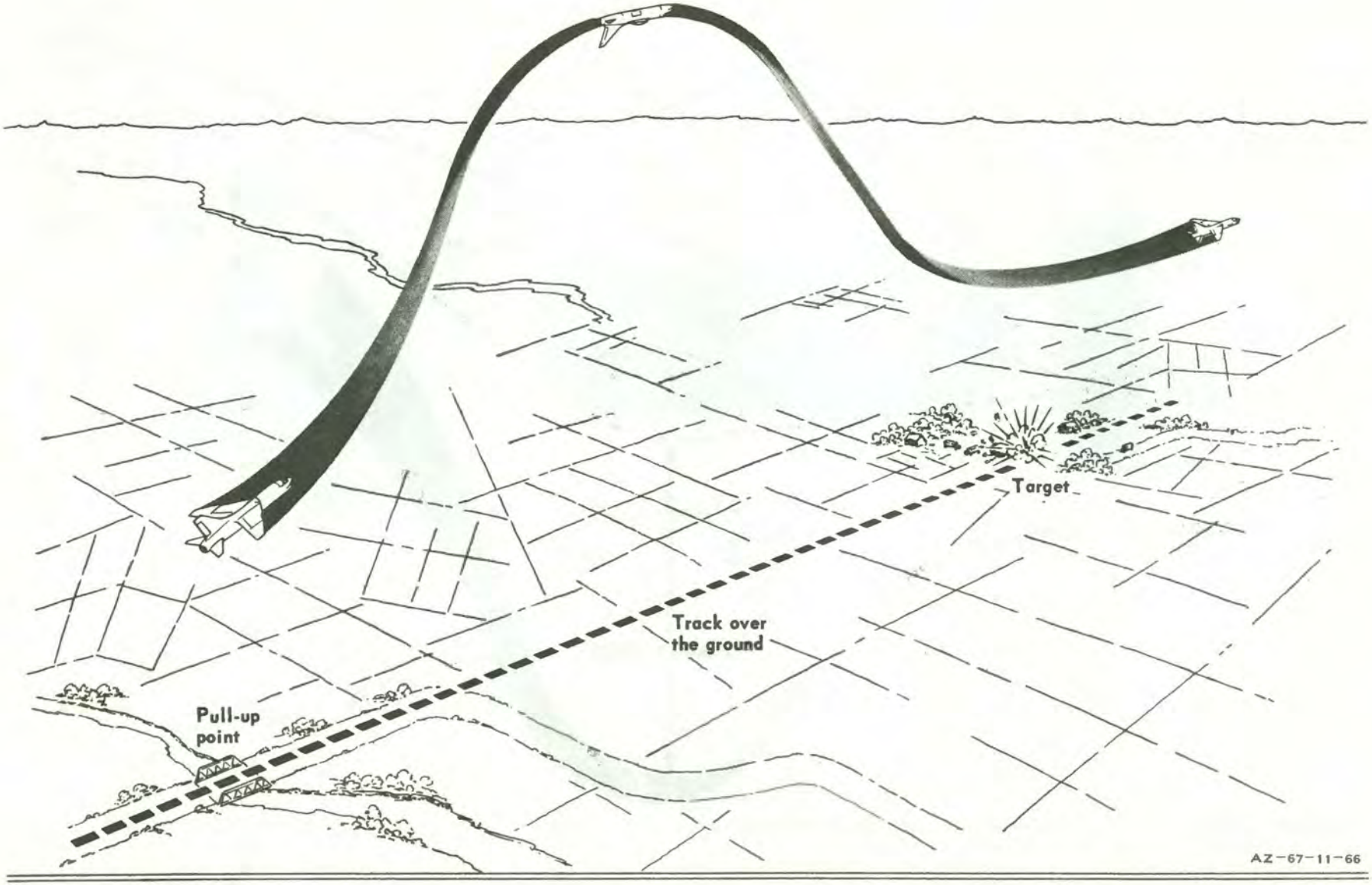


Figure 2–19

Off-Set, Pop-Up Maneuver

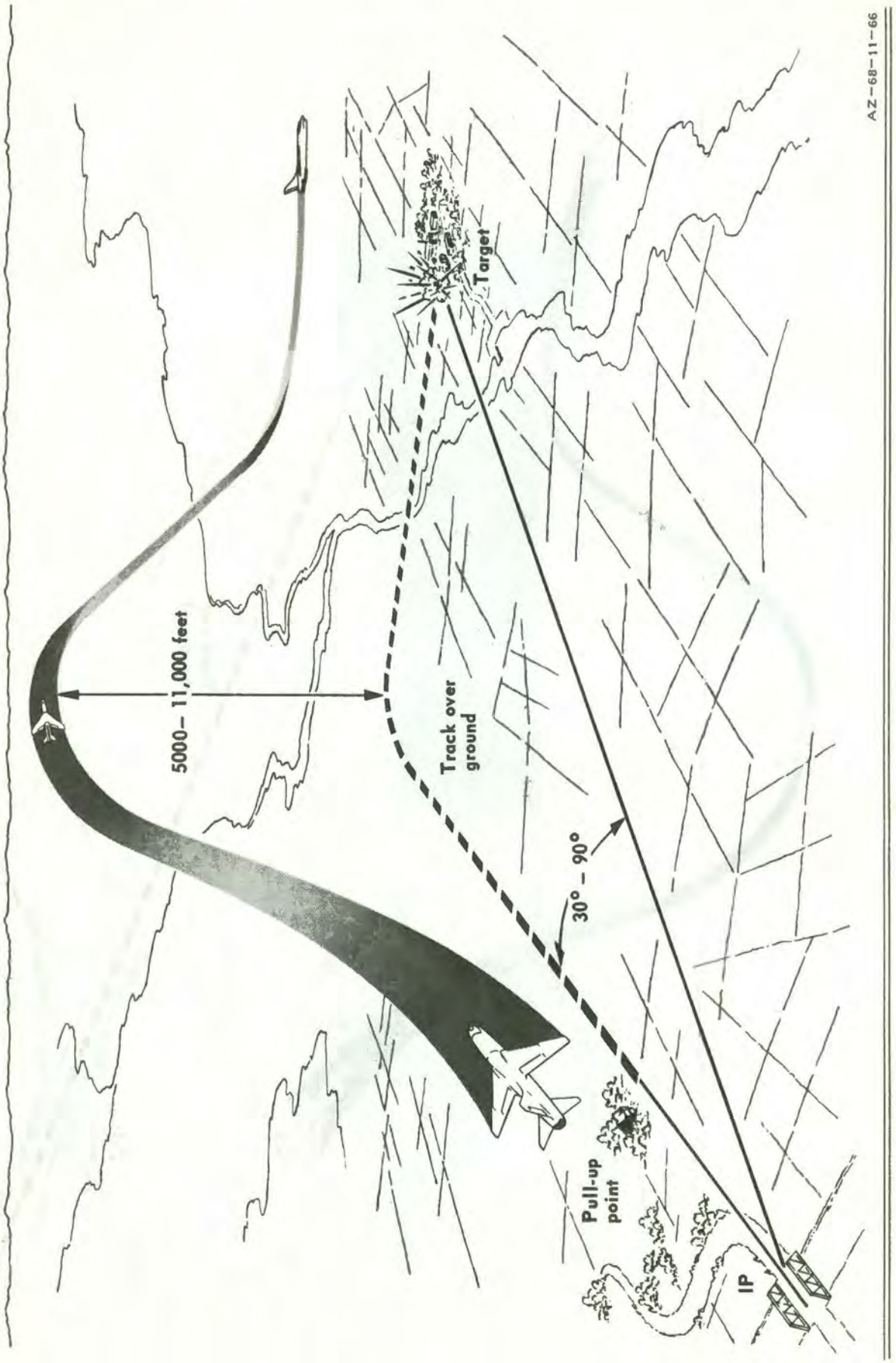


Figure 2–20

Pop-Up Low-Angle Attack

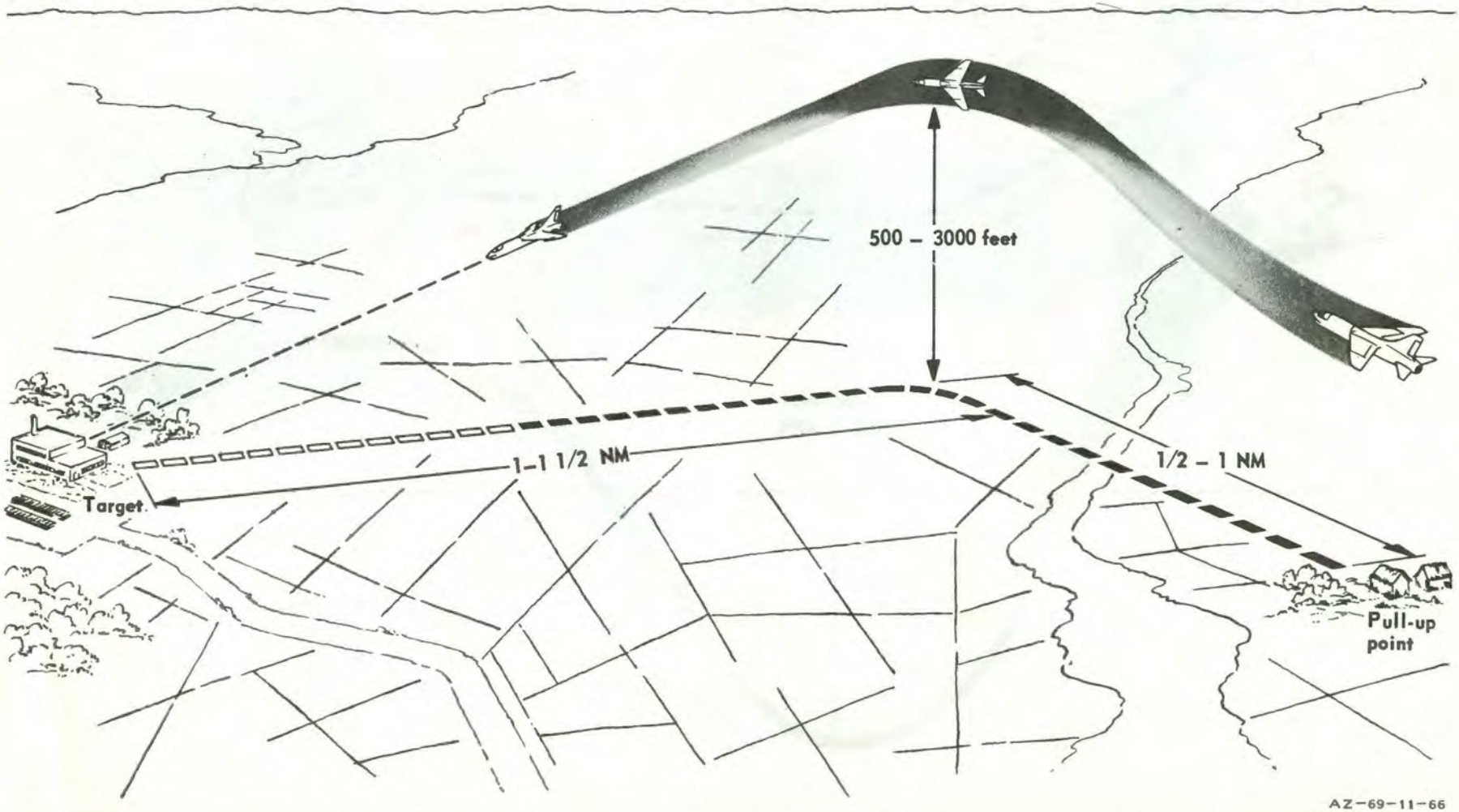


Figure 2–21

Pop-Up for Rockets or Glide Bomb

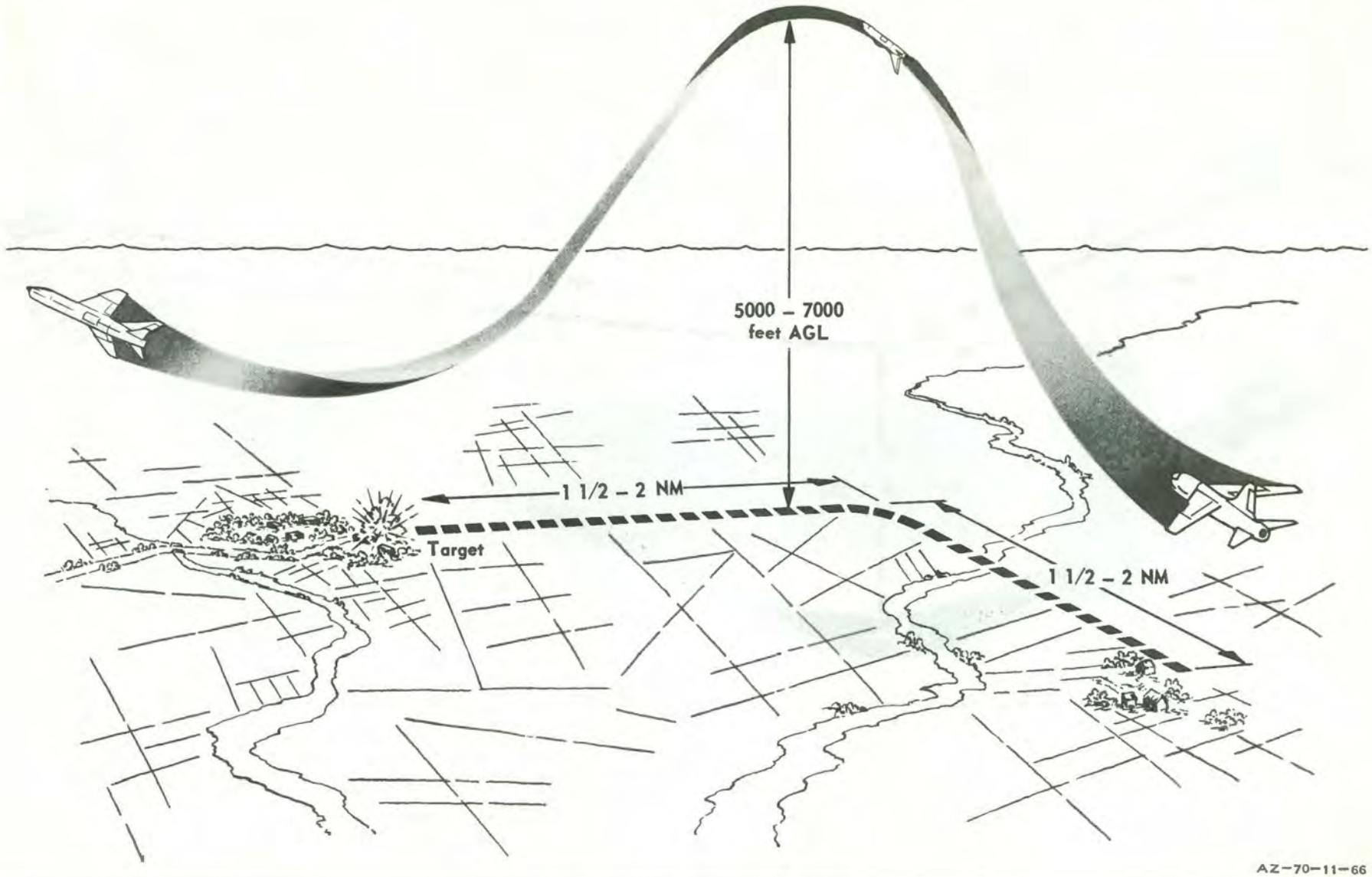


Figure **2–22**

Pop-up for High-Angle Dive Bomb

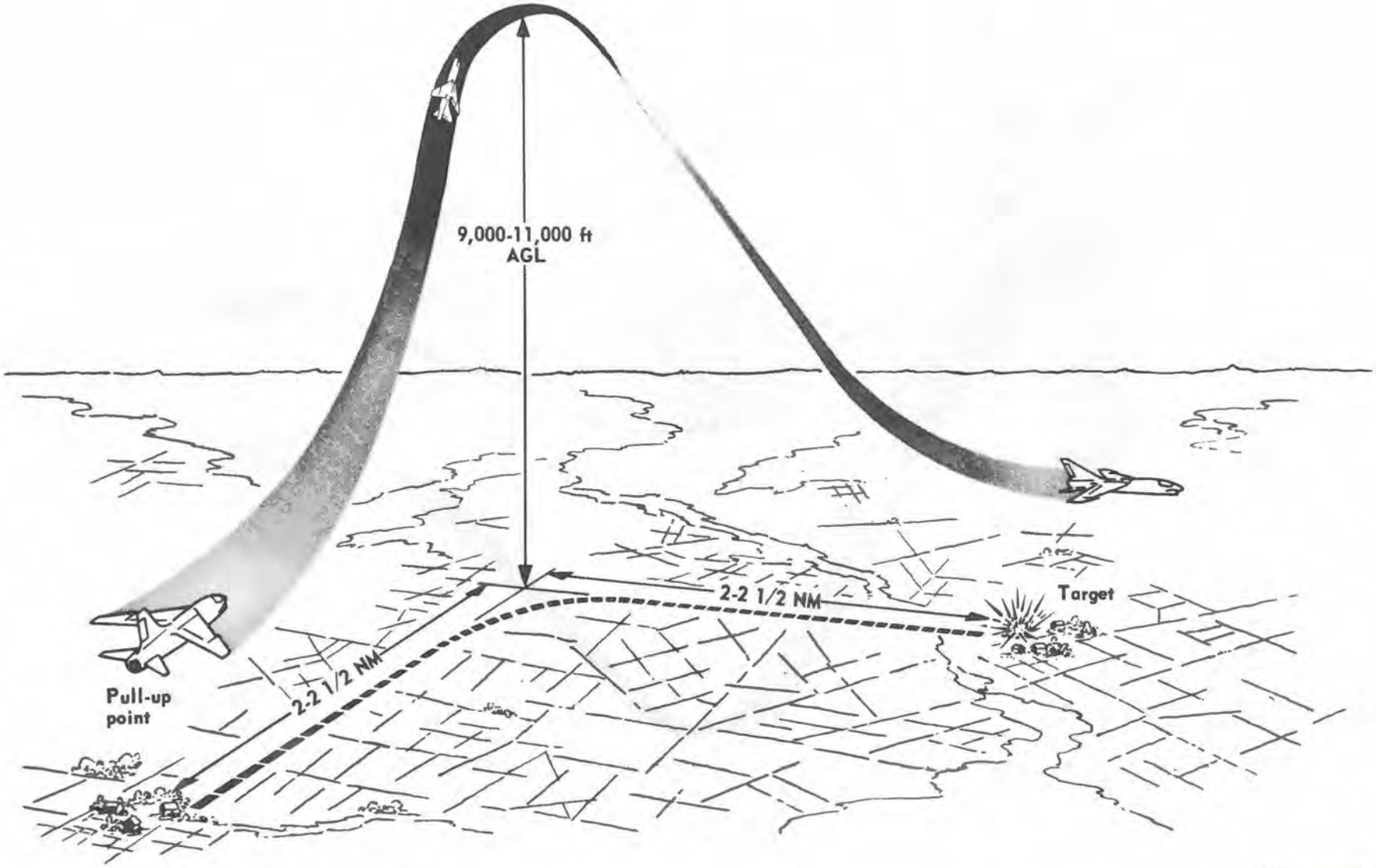


Figure 2–23

Unplanned Off-Set Pop-Up Maneuver

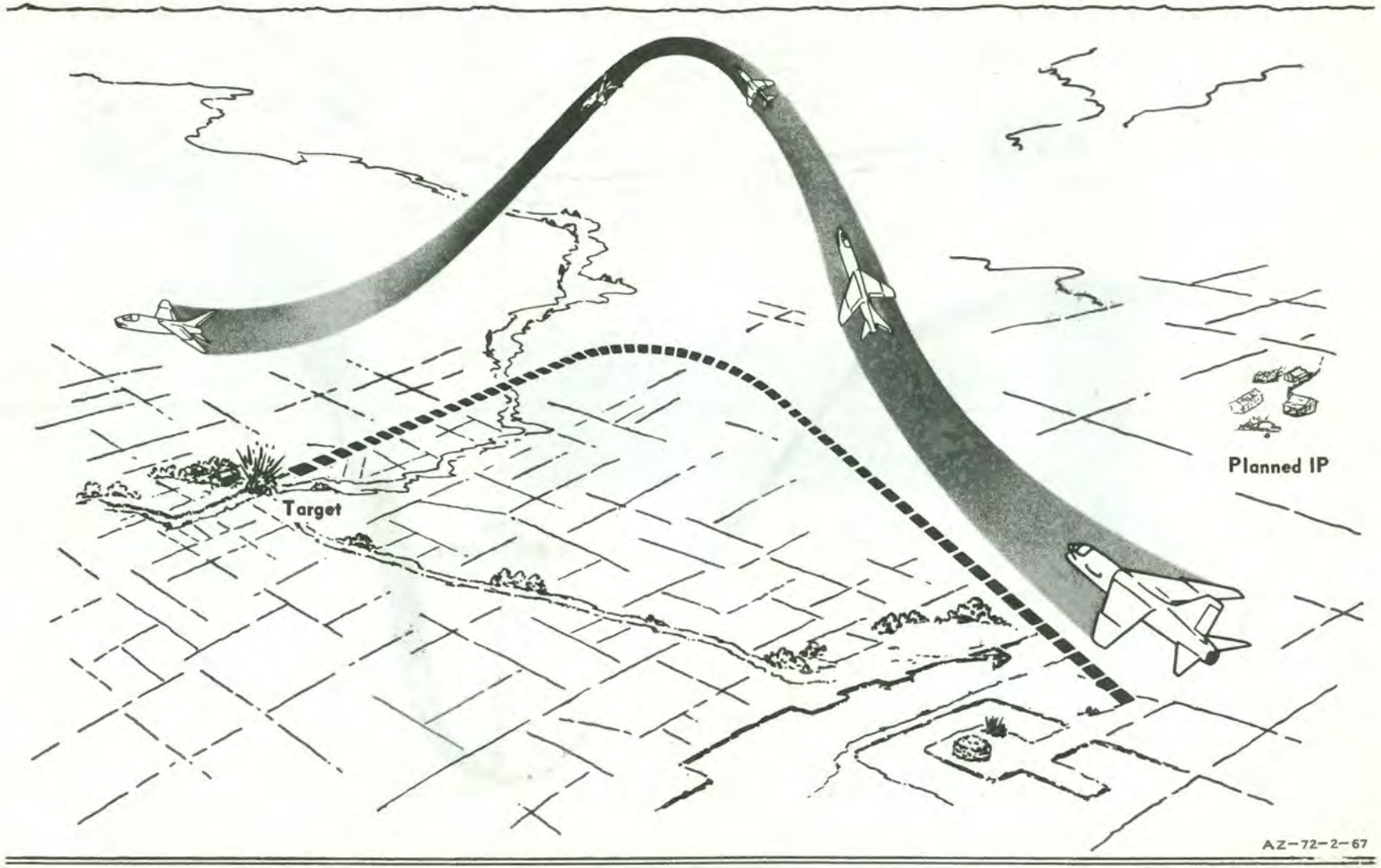


Figure 2-24

Reversal Pop-up Maneuver

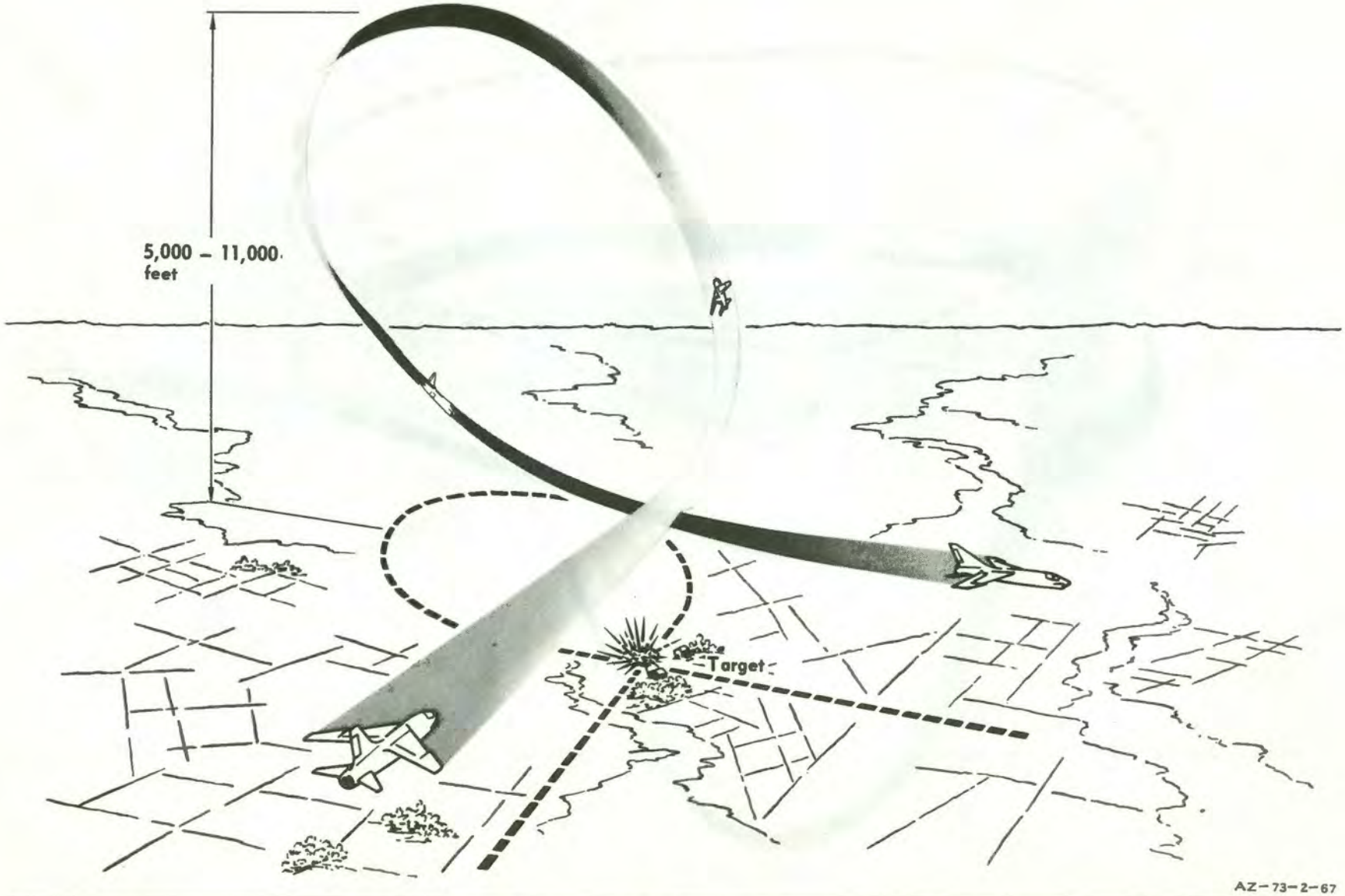


Figure 2–25

Repositioning Maneuver

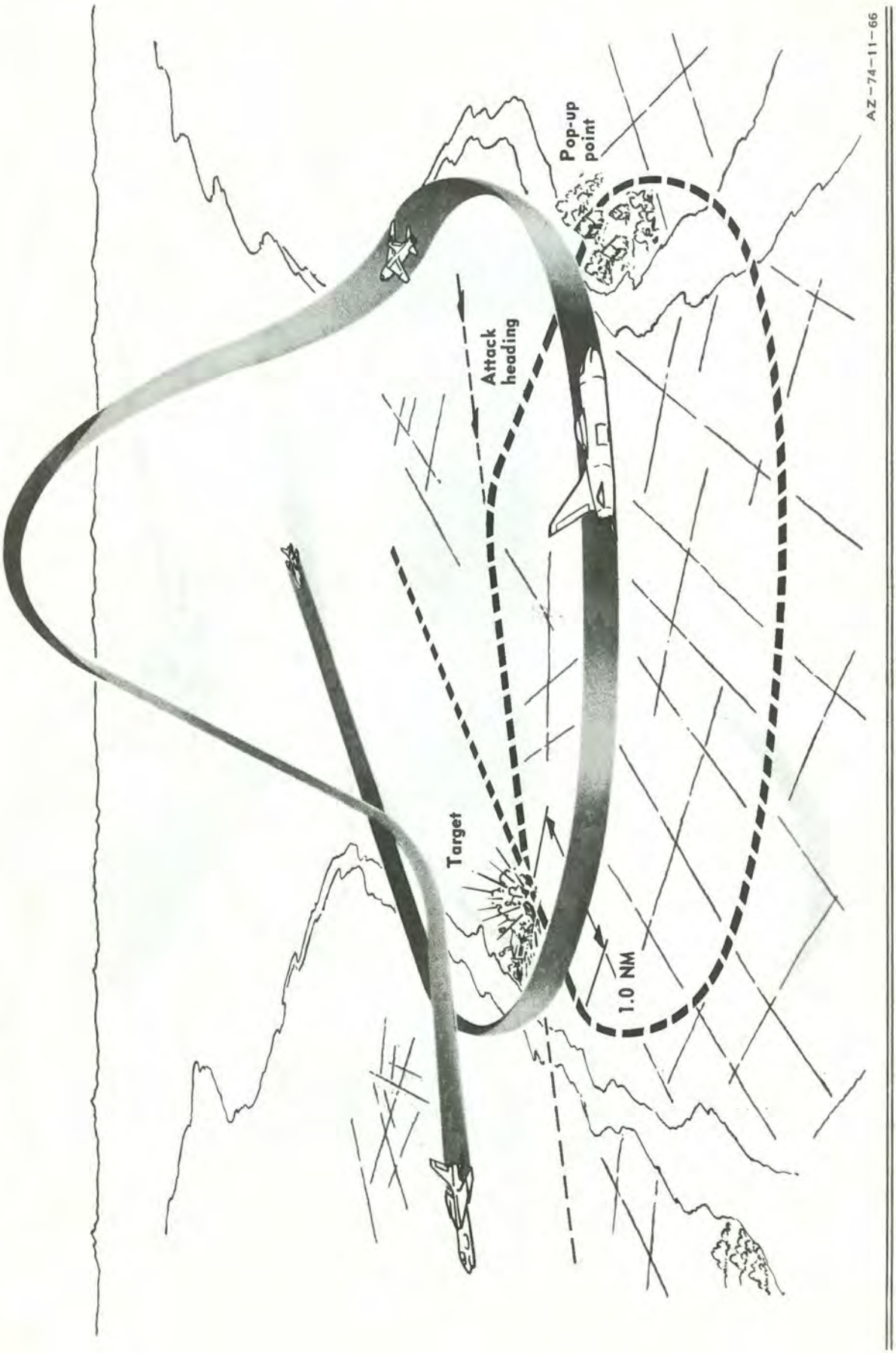


Figure 2–26

RECOVERY

WARNING

See rolling pull-out g restrictions in this section.

The three basic recovery maneuvers available to the pilot are:

a. Wings level 4g to 6g pull-up to a climbing attitude.

b. Straight away, full power, flat out recovery after a 4g to 6g level off.

c. A high g breakaway turn.

The tactical situation may dictate variations from all of these but minimum safe altitudes to escape weapon fragmentation and ricochet must be considered. Mil lead charts in Part 4 depict release unsafe areas and are based on a recovery pull-up where 4g is attained within 2 seconds after weapon release.

DELIVERY ERRORS

The factors that affect the accuracy of the dive delivery are: dive angle, release altitude, airspeed, coordinated flight, g at release, wing level attitude at release, wind and target motion. The mil lead selected for a certain weapon delivery is based on specified conditions of dive angle, release altitude, and airspeed. Corrections for deviations from these planned release conditions will be considered independently.

DIVE ANGLE ERROR

Dive angle deviations induce errors in all the planned release conditions. The sight computation, airspeed and release altitude are planned for a specific dive angle. If delivery is accomplished in a steeper dive than planned, the impact will be long. If the delivery dive is shallower than planned the opposite is true. See figure 2–27.

Dive angle corrections must be applied as soon as the initial error is recognized. One method of dive angle correction is illustrated in figure 2–28.

AIRSPEED ERROR

Mil lead is calculated for one airspeed. Release airspeed errors will change the velocity of the bomb, causing it to deviate from the planned trajectory.

If release airspeed is greater than planned, more velocity will be imparted to the weapon causing it to more closely follow the flight path of the aircraft thus causing an impact beyond the target (figure 2–29). Also, faster airspeed than planned will decrease angle of attack, causing a long impact in the same manner as does an increase in dive angle (figures 2–30 and 2–31). These two errors are cumulative.

The opposite is true of airspeeds slower than planned, the result being an impact short of the target.

RELEASE ALTITUDE ERROR

Mil lead is computed for a given altitude (slant range) and only from this range will the trajectory of the bomb intersect the sight line at the target. It should be kept in mind that the altimeter reading will lag considerably behind actual altitude in dive deliveries. If release altitude is lower than planned, slant range is decreased and the weapon will impact beyond the target and vice versa (figure 2–32).

UNCOORDINATED FLIGHT ERROR

A bomb, from the moment of release, will follow the aircraft track. If the aircraft is in a skid, the impact error will always be in the direction of the skid (figure 2–33).

If the aircraft is in a skid during gun or rocket deliveries, there will be an impact error between the aircraft track and the sight line (figure 2–34). This is the resultant of the two velocities imparted to these weapons by the initial velocity from the gun or rocket motor and the skidding velocity of the fighter. A rocket will head into the relative wind and the error will always be in the direction of the skid.

BANK ERROR

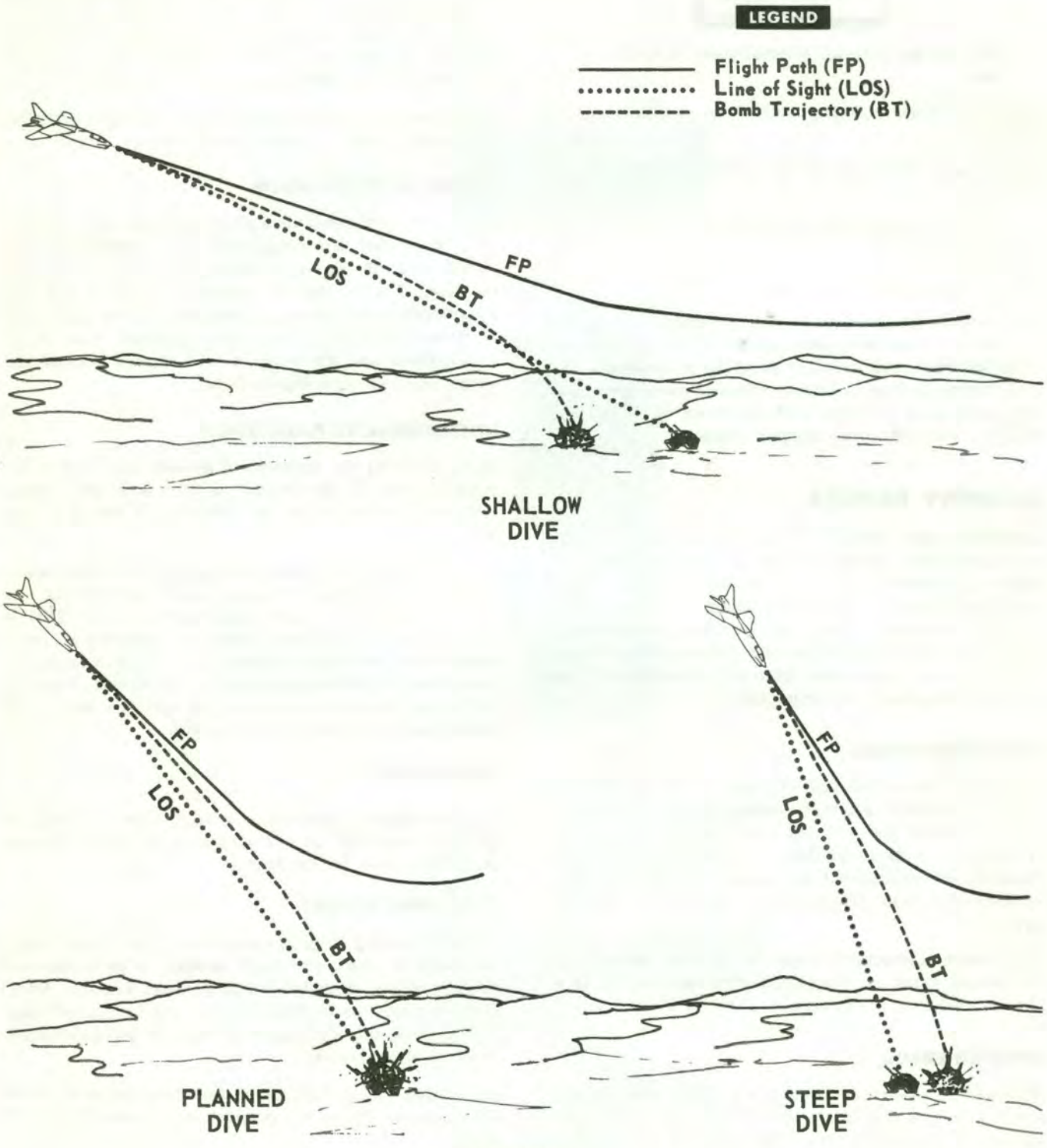
If the weapon is released in a bank with the planned mil lead reference on the target, a deflection impact error will result. See figure 2–35.

G LOADING ERRORS

An increase in g loading results in an increase in angle of attack in much the same manner as in a decrease in dive angle, thus producing a short impact. Additionally, holding increased g for any length of time will shallow the dive angle and add to the undershoot error or short impact.

Decreasing the g load from that planned will cause the opposite effects and produce an overshoot or long impact.

Dive Angle Error



NOTE

Based on a constant slant range and airspeed.

AZ-8-2-67

Figure 2-27

Dive Angle Corrections

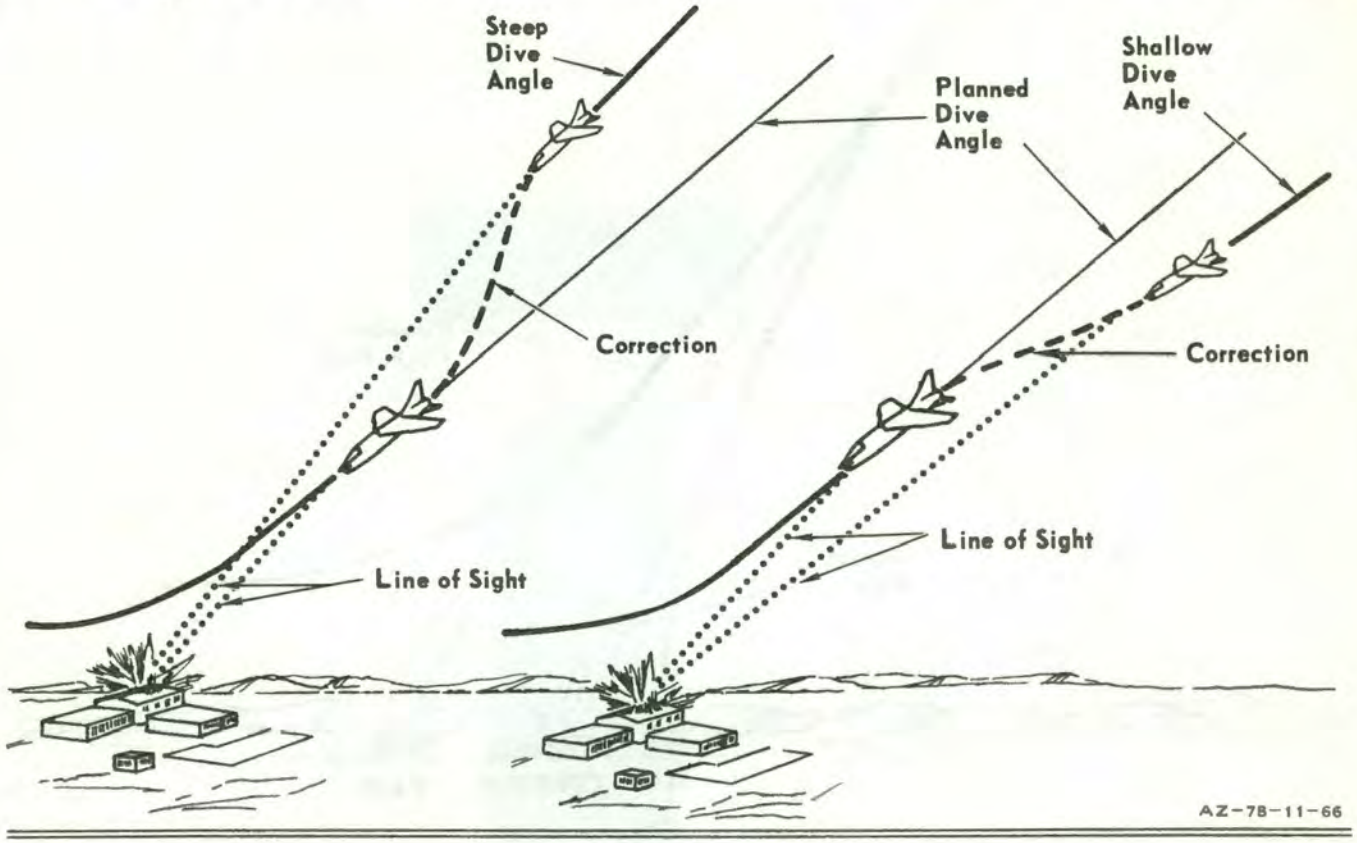


Figure 2–28

Release Airspeed Error

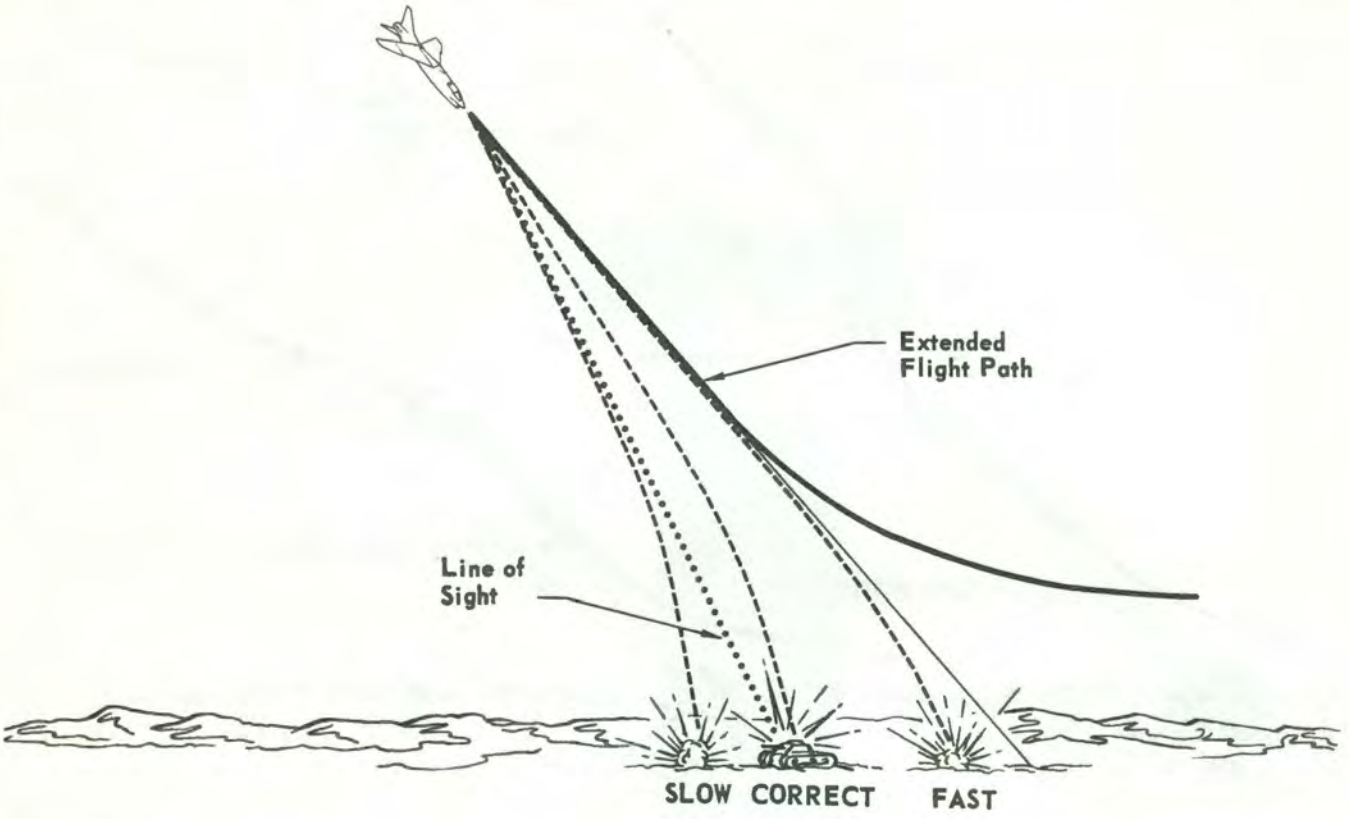
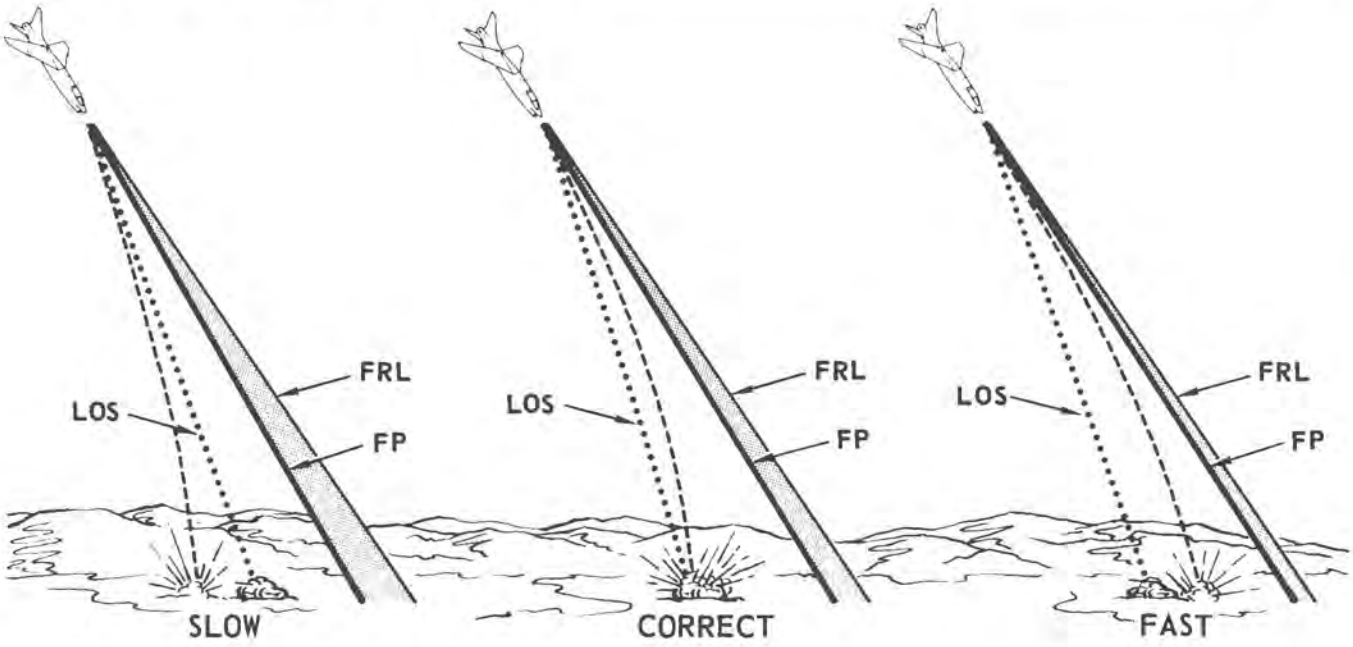


Figure 2–29

Airspeed vs Angle of Attack



NOTE

Observe the change in the angle between FRL and flight path

LEGEND

Flight Path (FP)
Fuselage Reference Line (FRL)
Line of Sight (LOS)
Bomb Trajectory

AZ-4-9-66

Figure 2–30

Line of Sight vs Airspeed Error

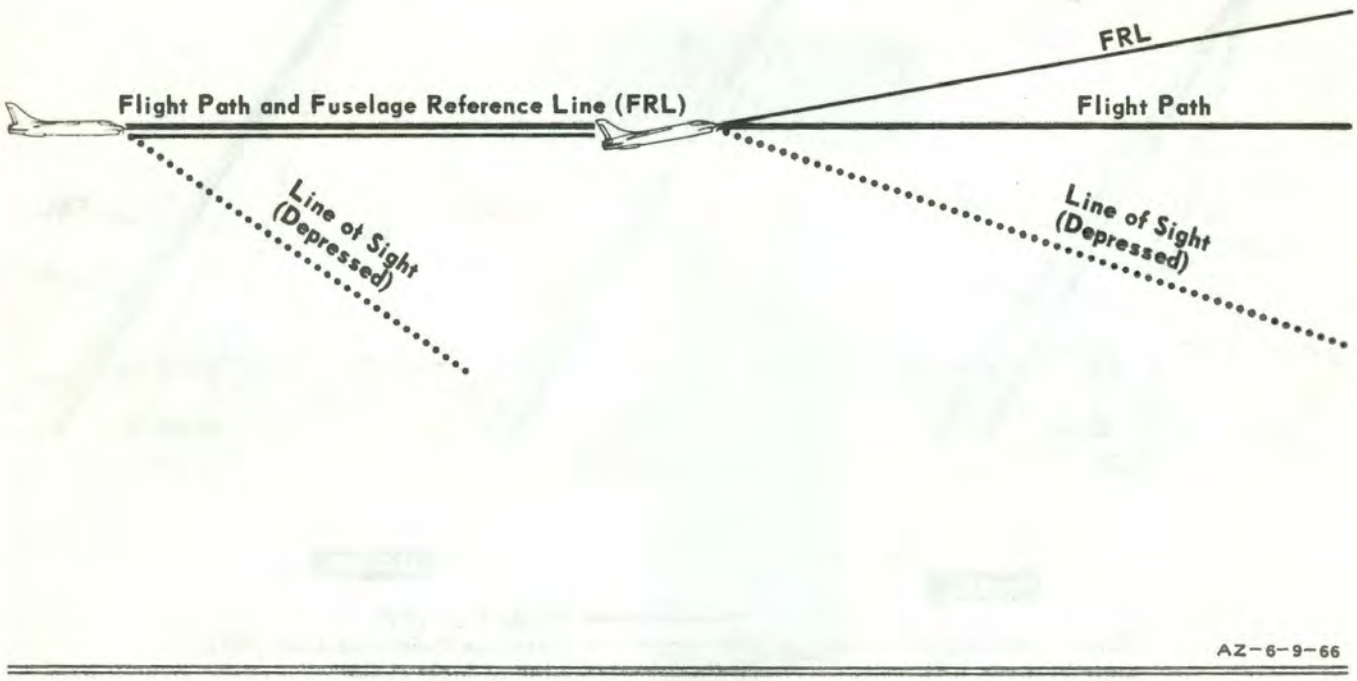


Figure 2-31

Release Altitude Error

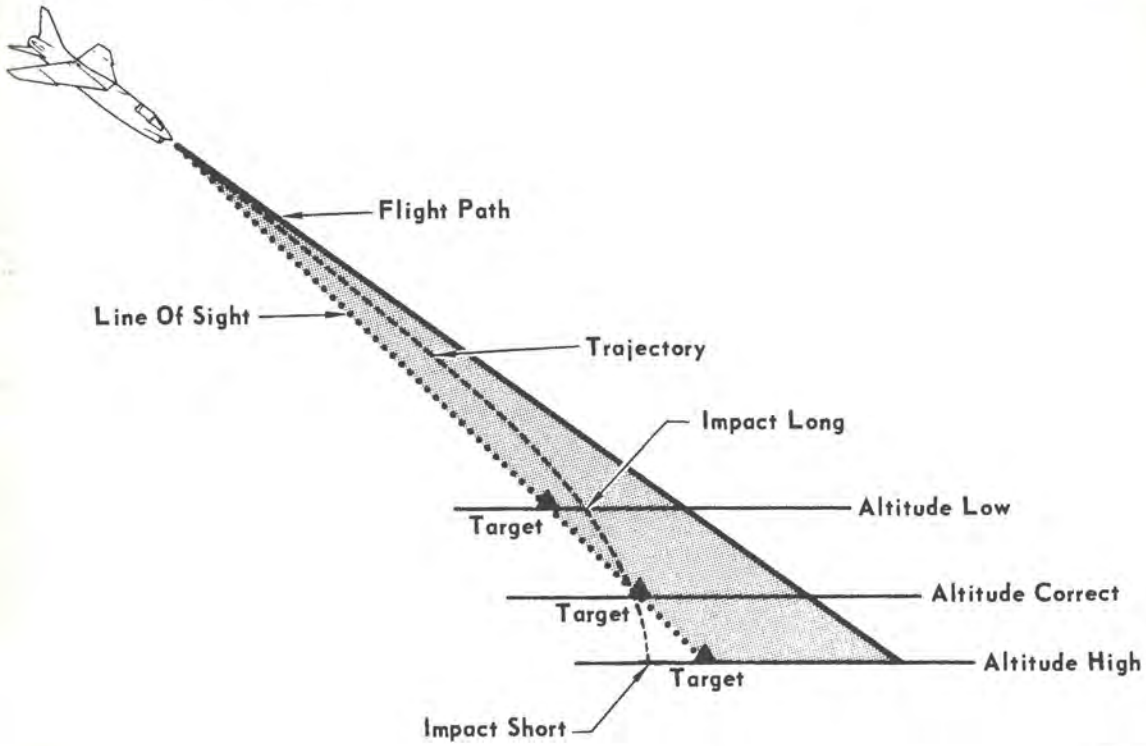
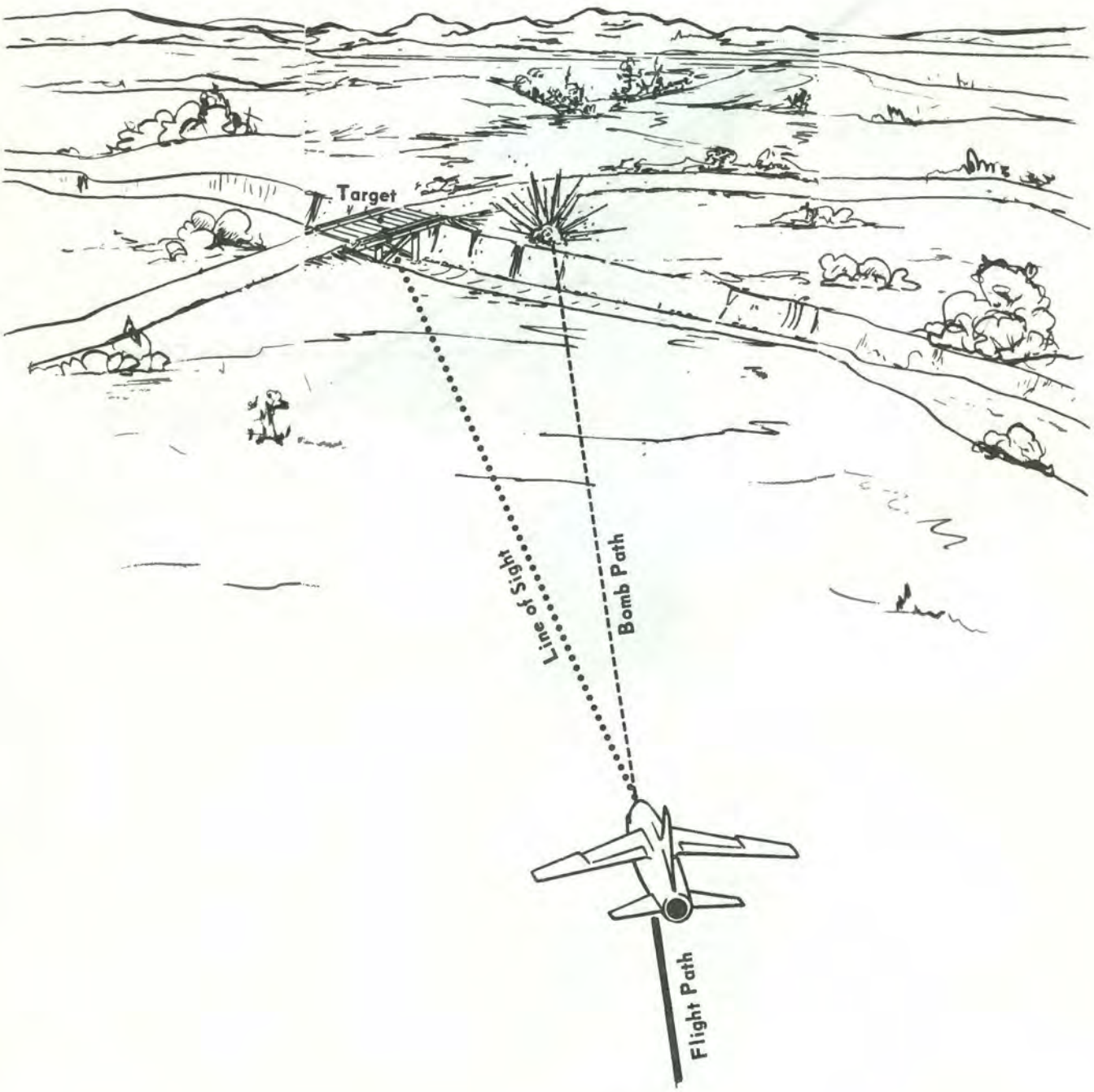


Figure 2–32

Effect of Skid on Bomb Impact



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Figure 2-33

Effect of Skid on Bullet and Rocket Impact

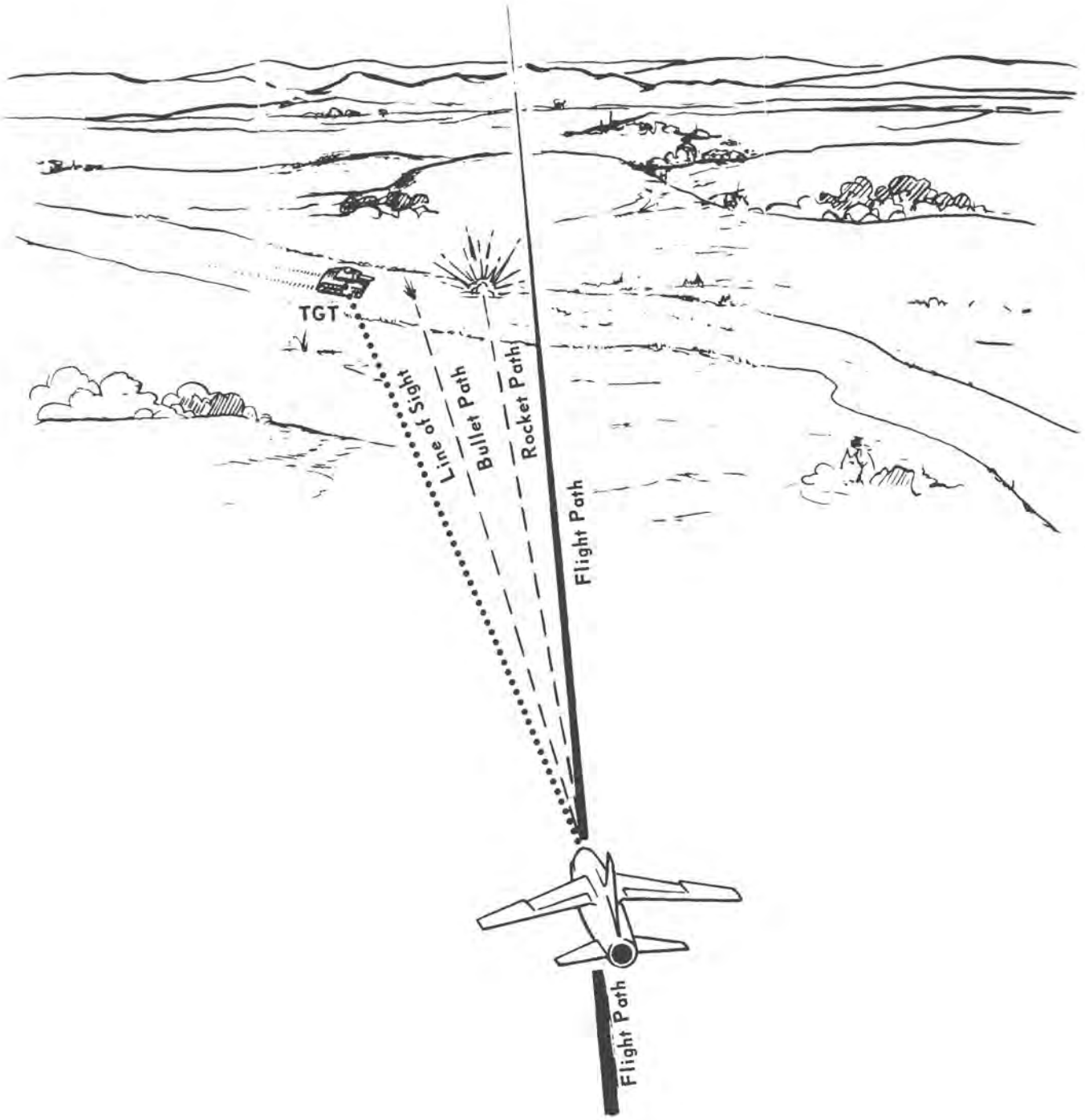


Figure 2–34

Effect of Releasing in a Bank

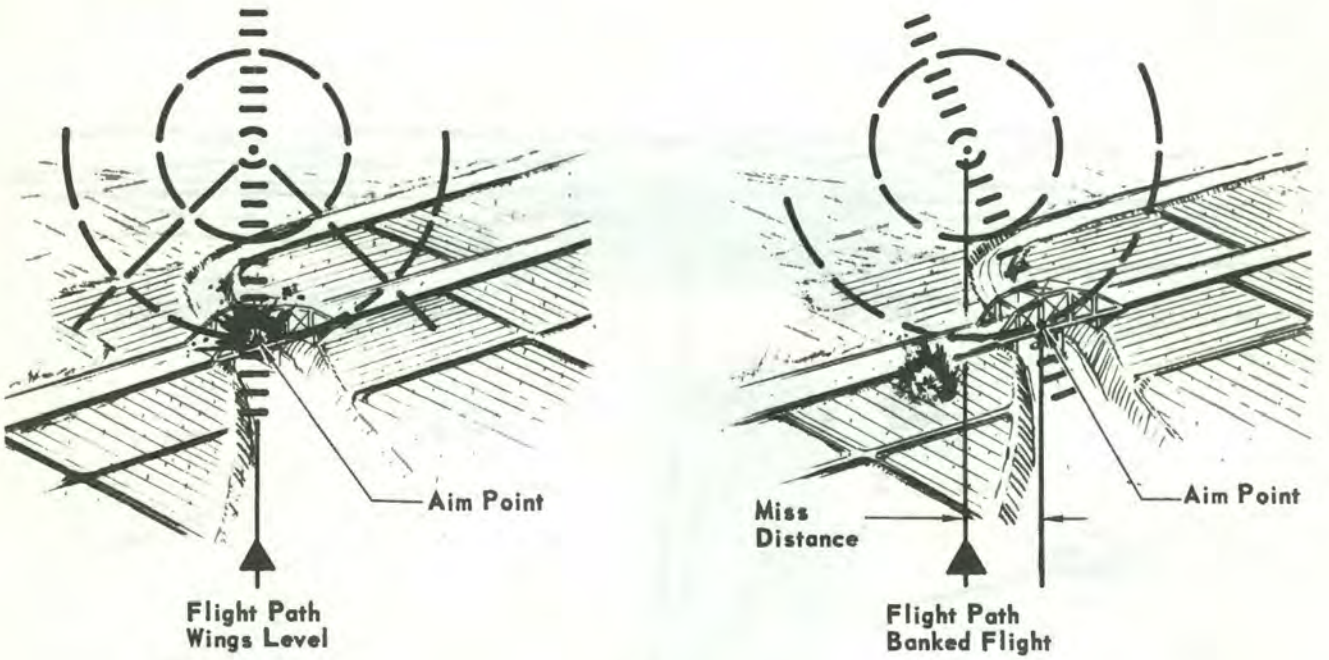


Figure 2–35

LEVEL DELIVERY

Level attacks encompass dive angles of less than 10 degrees. Entry can be attained by several methods: a climbing entry, level entry, or a diving approach followed by level off prior to reaching the target. Entry should be established early enough in the attack to allow the pilot sufficient time to perform minor altitude, airspeed and track corrections before stabilizing prior to weapons release (figure 2–36).

ENTRY

Locating the target and establishing an accurate run-in are the first requirements for effective low-level delivery. An IP, with a known location relative to the target, may be required for accurate approaches to targets with little or no vertical development. The attack should be started at the maximum range consistent with terrain and visibility conditions. Descent, if necessary, should be controlled so as to arrive on the desired run-in heading, wings-level, 100 to 200 feet above release altitude (level terrain). From this altitude, at a position approximately 5,000 feet from the target, final descent to release altitude can be made. During the descent, make corrections necessary to establish a stabilized track to the target.

TRACKING

Release airspeed should be established as early in the attack as possible. Then, as the run-in progresses, only small corrections will be necessary to stabilize track and release speed. The pilot can then devote most of his attention to tracking the target. The primary considerations during this initial portion of the attack are: airspeed, altitude, level flight, and crosswind.

The release point must be anticipated as the mil lead point approaches the target, and the weapon release button must be pressed at the instant the desired sight picture is attained. In turbulent air, the pilot should average out erratic movements of the mil lead point to determine the correct release point. The final portion of the run is particularly critical since difficulty in stabilizing pitch can result in an early or late release.

RECOVERY

The same maneuvers used in dive recovery will apply depending upon the tactical situation. Normally the recovery from a level delivery at low altitude will consist of a wings level, full power, 4g to 6g pull-up to a climbing attitude. Once the nose is above the horizon, evasive action is started.

LEVEL DELIVERY ERRORS

The level delivery maneuver is similar to the dive delivery except that the dive angle is zero. The basic factors that affect the accuracy of the dive delivery also affect level delivery accuracy. Generally, deflection errors will be smaller in level deliveries and range errors will be larger. See figures 2–37 and 2–38 for errors produced by deviations in release conditions.

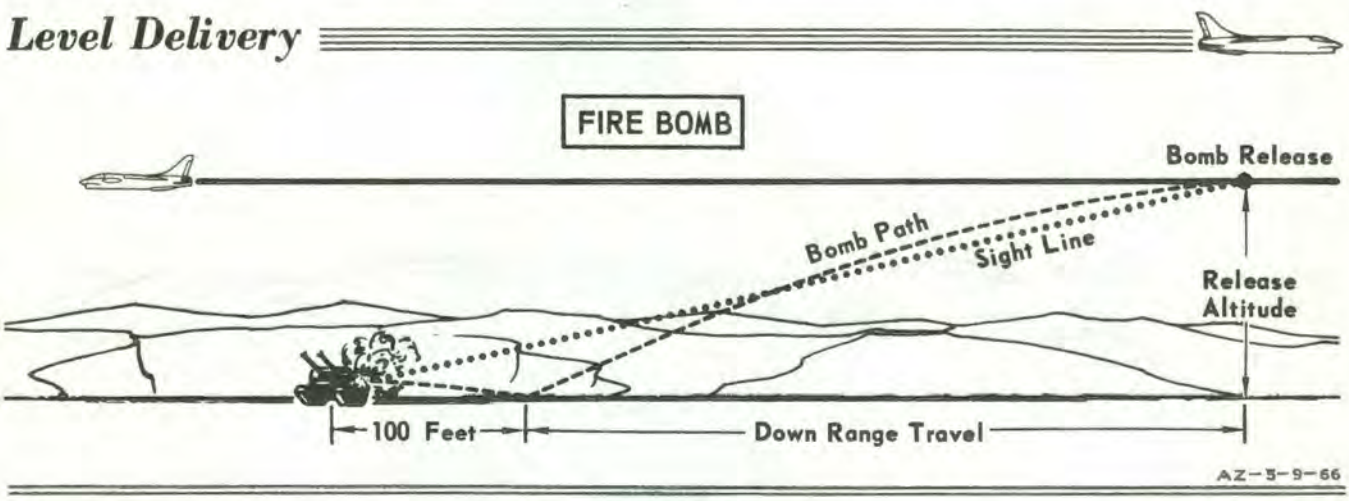
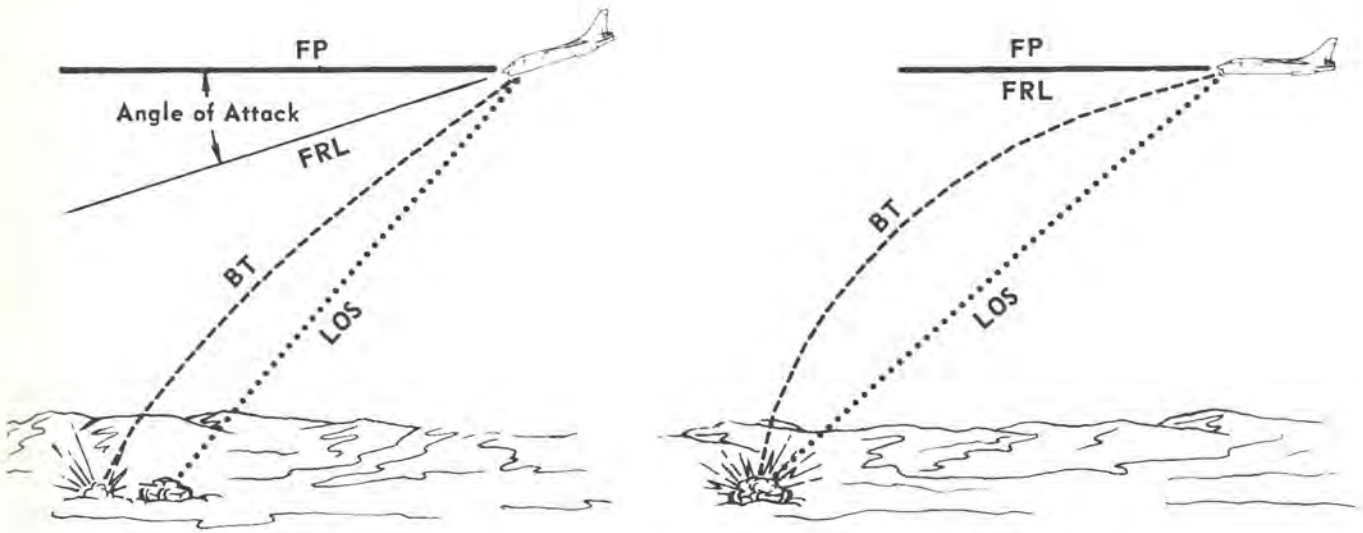
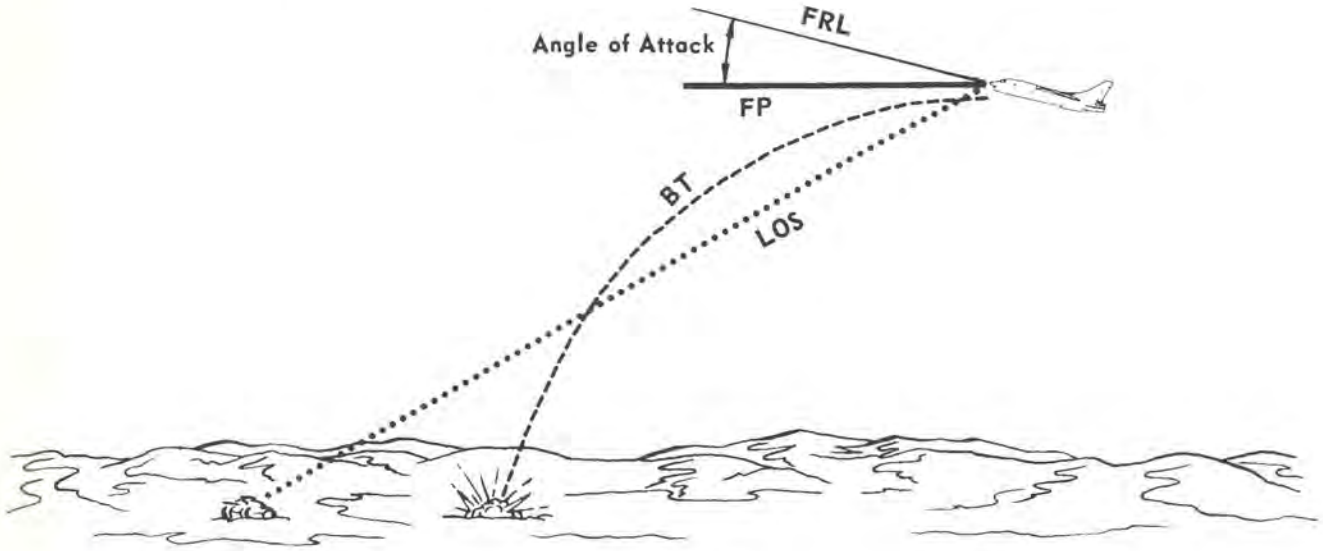


Figure 2–36

Release Airspeed Error for Level Bombing





LEGEND

- Flight Path (FP)
- Fuselage Reference Line (FRL)
- Line of Sight (LOS)
- Bomb Trajectory (BT)

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Figure 2–37

Release Attitude Error

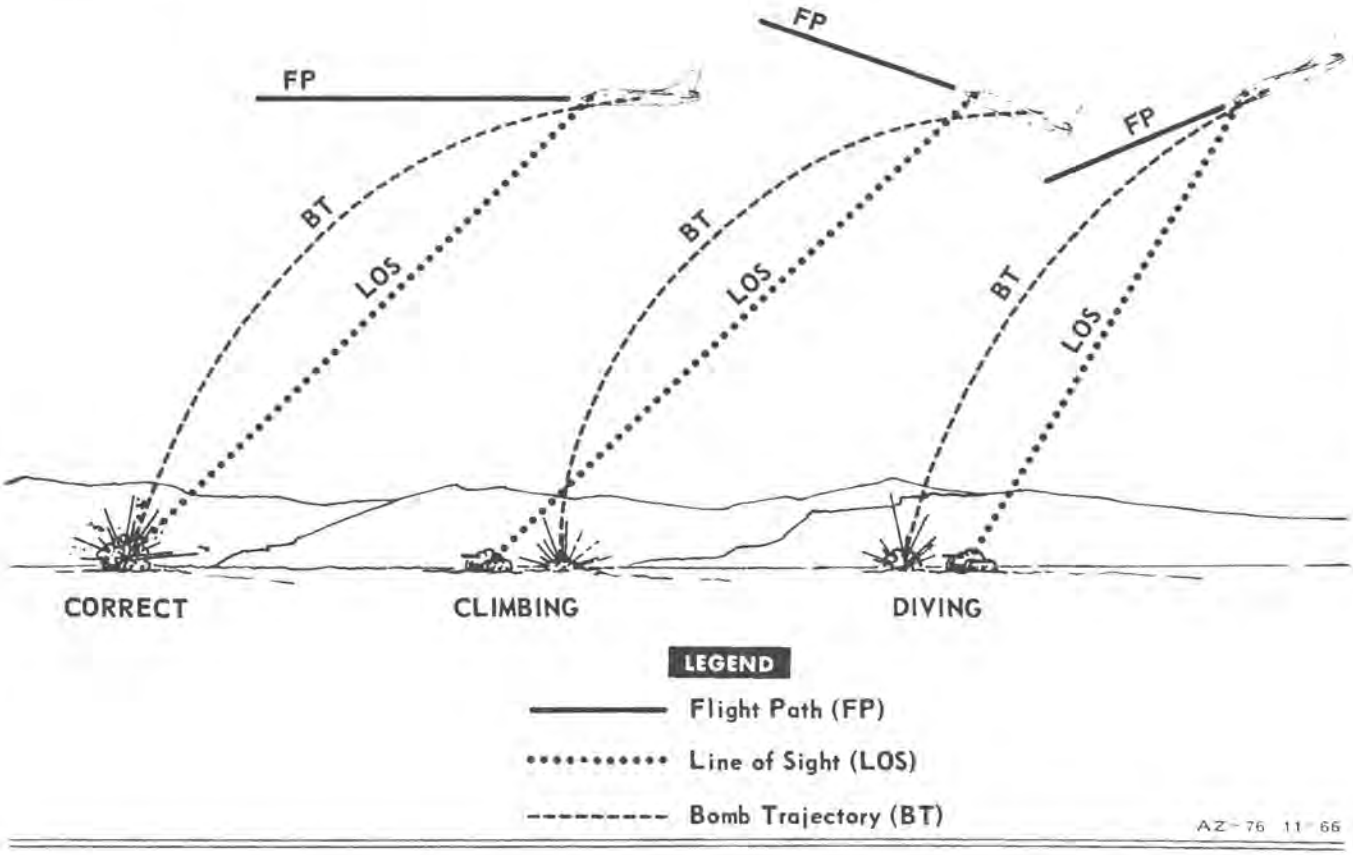


Figure 2–38

WIND AND TARGET MOTION

Wind drifts the aircraft in its dive prior to release and drifts the weapon in its trajectory after release. An offset aim point upwind of the target is selected to compensate for the wind effect. To counteract the effects of a headwind the roll-in point should be closer to the target. For a tailwind the opposite is true. See figure 2–39.

Offset aim point (feet) can be computed using the following formula:

$$\text{CORRECTION (FEET)} = V_{wind} \times \text{Time of Fall of the Weapon (Sec)} \times 1.69$$

Offset aim point (mils) can be computed using the following formula:

$$\text{CORRECTION (MILS)} = \frac{\text{Correction (feet)}}{\text{Slant Range}} \times \text{SIN } \theta \times 1000$$

Where: $\theta = \text{Arctan} \dfrac{\text{Release Height}}{\text{Horizontal Range}}$

Target motion is corrected for in a similar manner to wind correction. An off-set aim point is selected ahead of the moving target. This off-set aim point should be selected based on the estimated location of the target at impact.

Tested delivery data tables in Part 4 of this section give wind correction values in feet per 10 knots of wind.

STRAFING

INTRODUCTION

The chief characteristics of aircraft guns are their versatility, accuracy, and sustained concentration of fire, which makes them highly effective against a wide variety of targets. The three basic types of strafing that may be required in combat are (1) suppression, (2) line targets, and (3) point targets. Suppression type strafing is generally used in conjuction with bomb or rocket runs to "keep their heads down" and tracking is relatively unimportant. When strafing a line

Drift Method of Crosswind Correction

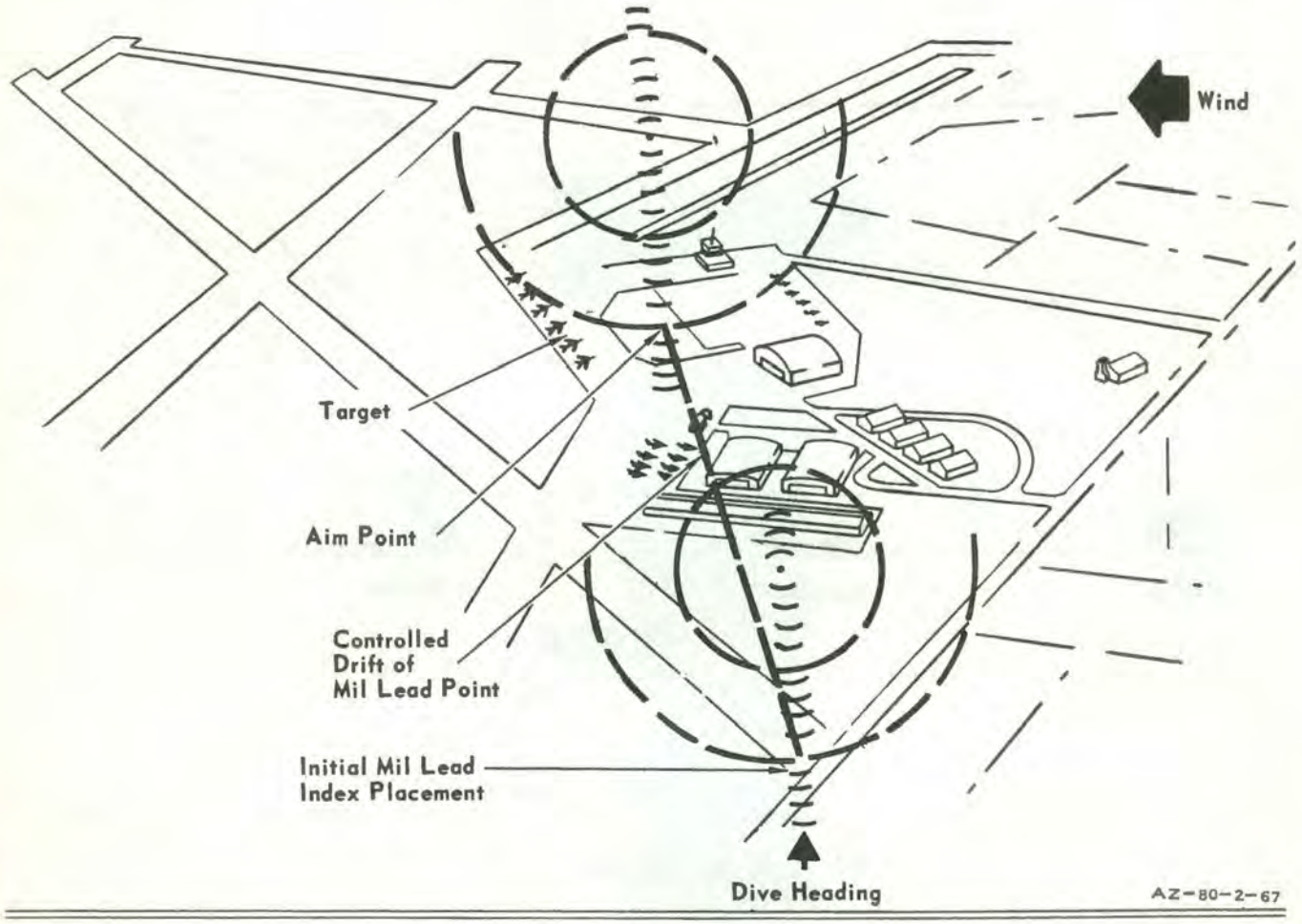


Figure 2–39

target such as a truck convoy, a column of troops, or a line of ships, firing is usually commenced at extremely long slant ranges; and series of bursts, either long or short, are repeated until recovery is initiated. In this type of strafing, the pilot can use actual impacts to adjust the aim point. When strafing a point target, the pilot attempts to meet specific firing parameters with a predetermined sight angle. The pipper is held on the target during the firing burst. One feature which enhances delivery effectiveness at long ranges is that the pilot can assess target damage immediately after cease fire. The pilot can also make corrections during burst by observing the flight of the APT projectiles. Effective low angle strafing range extends to approximately 4,000 feet; however, the effective strafing range will increase with corresponding increase in dive angle up to 12,000 feet in a 60-degree dive. The choice of delivery maneuver will depend on the target, the enemy defenses, and the weather conditions in the target area. For example, steep dive, coupled with high airspeed, should be used in attacking ships; whereas, a shallow dive which is more likely to produce waterline hits, is more effective against small boats (or junks). Camouflaged targets are more easily seen when a low angle attack is conducted at medium speed. Trenches or AAA positions should be strafed in steeper dives in order to pinpoint the target. Recovery should be initiated as high as possible, consistent with the desired accuracy, in order to minimize the effectiveness of the enemy small arms and automatic weapons fire. Against ammunition dumps, the steeper dive maneuvers are recommended with recovery being completed above 2,000 feet AGL in order to avoid explosion fragments.

ENTRY

The strafing attack is relatively easy to perform and may be initiated from almost any position with a minimum of preplanning. However, for maximum effectiveness the pilot should strive for consistent dive angles,

slant ranges, and airspeeds. This is best accomplished by initiating the attack from an angle off the desired firing heading of at least 45 degrees. The roll-in technique should be varied to meet existing conditions. That is, if the roll-in position appears too far out, the turn-in should be almost level until the desired dive angle is intercepted, or if too close in, the nose should be lowered immediately and pulled through to the desired dive angle. Tracking time will be lost if the roll-in is made too gradually. Conversely it is difficult to make a precise rollout from a hard turn, and entry airspeed will be difficult to maintain. A 2 to 3g turn will normally allow an easily controlled roll-in entry and rollout on the desired attack heading.

TRACKING

Three to five seconds should be available for tracking after rolling out on the attack heading. The recommended power settings should be set during roll-in and adjusted early in the tracking phase. Normally one airspeed check should be made about midway between roll-in and firing. Depending on the rate of approach to the desired firing airspeed, a power correction should be made and then attention should be concentrated on tracking, firing altitude, and firing. As the roll-in is completed, the pipper is initially placed on or slightly above (5 to 10 mils) the target, and the aircraft is trimmed slightly nose heavy for the release airspeed. As the correct dive angle is established, the pipper is allowed to drop 10 to 20 mils (pilot preference) below the target, and primary attention is then given to deflection alignment. As the aircraft approaches the firing altitude the pipper is allowed to move up to the desired aiming point. The pipper should reach the aiming point just before the aircraft reaches the firing altitude and must be held steady during firing.

FIRING

Firing at the proper slant range is very important; therefore, the firing conditions of dive angle and release altitude are critical. If firing is commenced at a greater range than desired, the initial impacts will be short of the target unless an aiming correction has been made. Additionally, pattern density will be decreased due to increase dispersion, which will result in a larger impact area and reduced effectiveness. Firing at ranges below safe minimum slant range will increase chances of ricochet damage. At present, the best method of arriving at the proper firing slant range is to be on dive angle and fire at the proper altitude AGL. The most important factor in accurate point target strafing is to have the pipper on the target when firing is commenced and to keep it there for the duration of the firing burst. A slight amount of forward trim is desirable when firing longer bursts. This will help concentrate bullet impacts and will tend to prevent "walking-the-burst."

COMMENCE FIRE ALTITUDE

To determine the commence fire altitude, the altitude lost during firing must be calculated. Altitude lost during firing is a function of airspeed, dive angle, and firing burst length. Figure 2–40 provides altitude lost information for firing true airspeeds of 400, 450, and 500 KTAS and dive angles of 10 to 45 degrees. Downrange travel of the aircraft during firing is also a function of airspeed, dive angle, and firing burst time. This information can also be obtained from the illustration.

CEASE FIRE ALTITUDE

Figure 2–150 shows minimum cease fire altitudes which preclude aircraft entry into the fragment envelope or allow the delivery aircraft to recover above ground level, whichever is greater. Ricochet should not be expected from soil impact when projectiles are fired at dive angles of 30 degrees or greater. Information on ricochet hazards for dive angles less than 30 degrees is not presently available.

RECOVERY

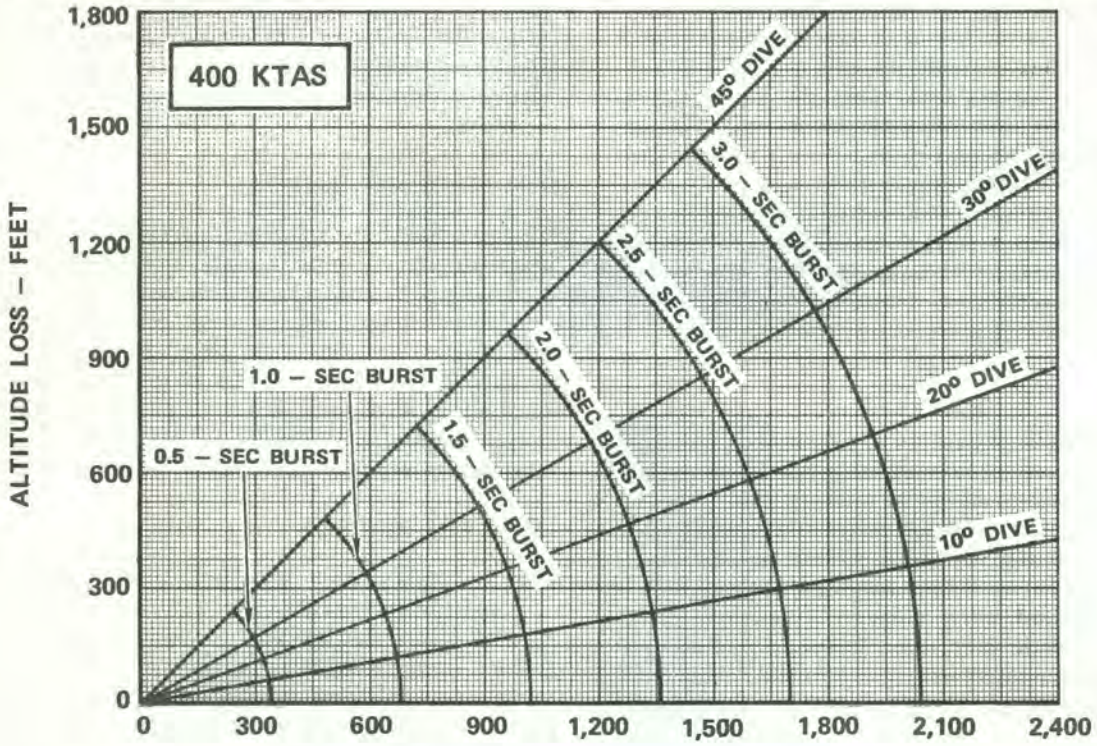
Recovery should be initiated with a pullup as soon as the trigger is released. If a long burst has been fired, bullet impact may be seen before the aircraft nose banks out the target. The recovery should be made by breaking away from, instead of over the target, since this reduces the probability of damage from ricochets, fragments, or an exploding target. It also complicates the prediction problem for defensive ground fire. Where effective missile defenses exist, execute a hard turn to low altitude after recovering to level flight. For undefended target, reposition and reattack as desired.

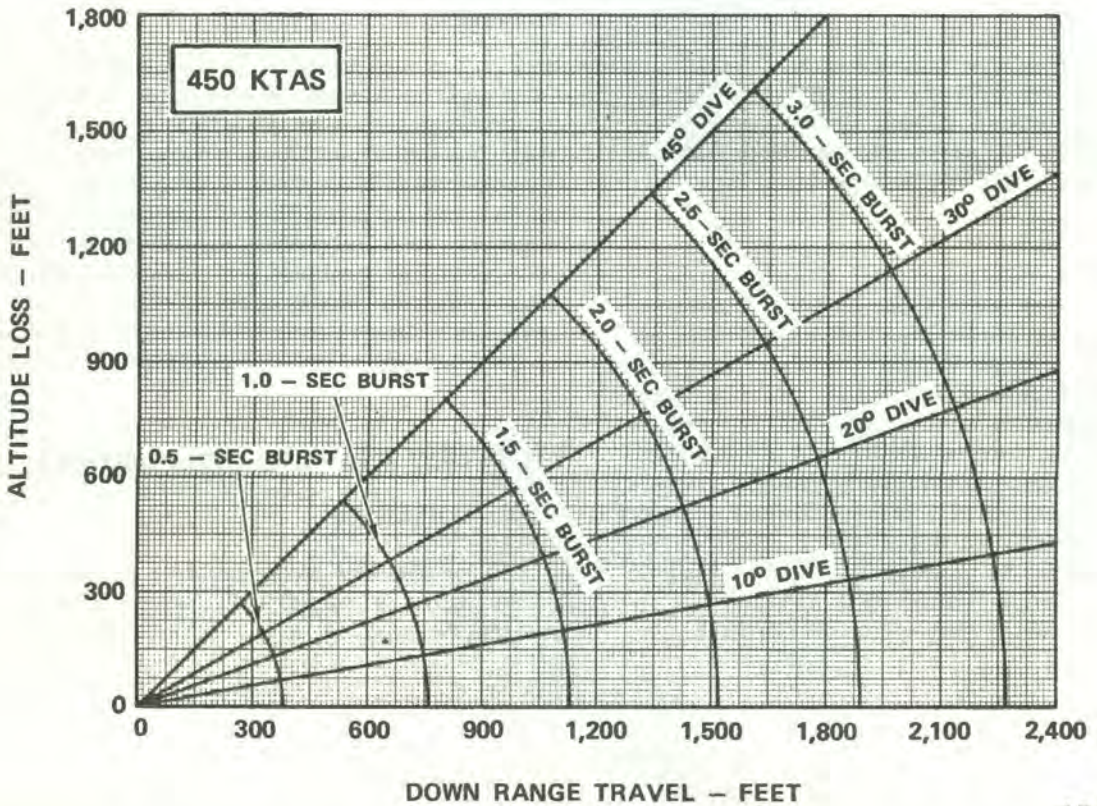
MULTIPLE RELEASE CONSIDERATIONS

MANUAL RELEASE

It will be desirable in some types of delivery to lay bombs across a target with spacing between bomb impacts. Since there is no cockpit intervalometer in

Strafing Down Range Travel and Altitude Loss





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Figure 2–40 (Sheet 1)

Strafing Down Range Travel and Altitude Loss

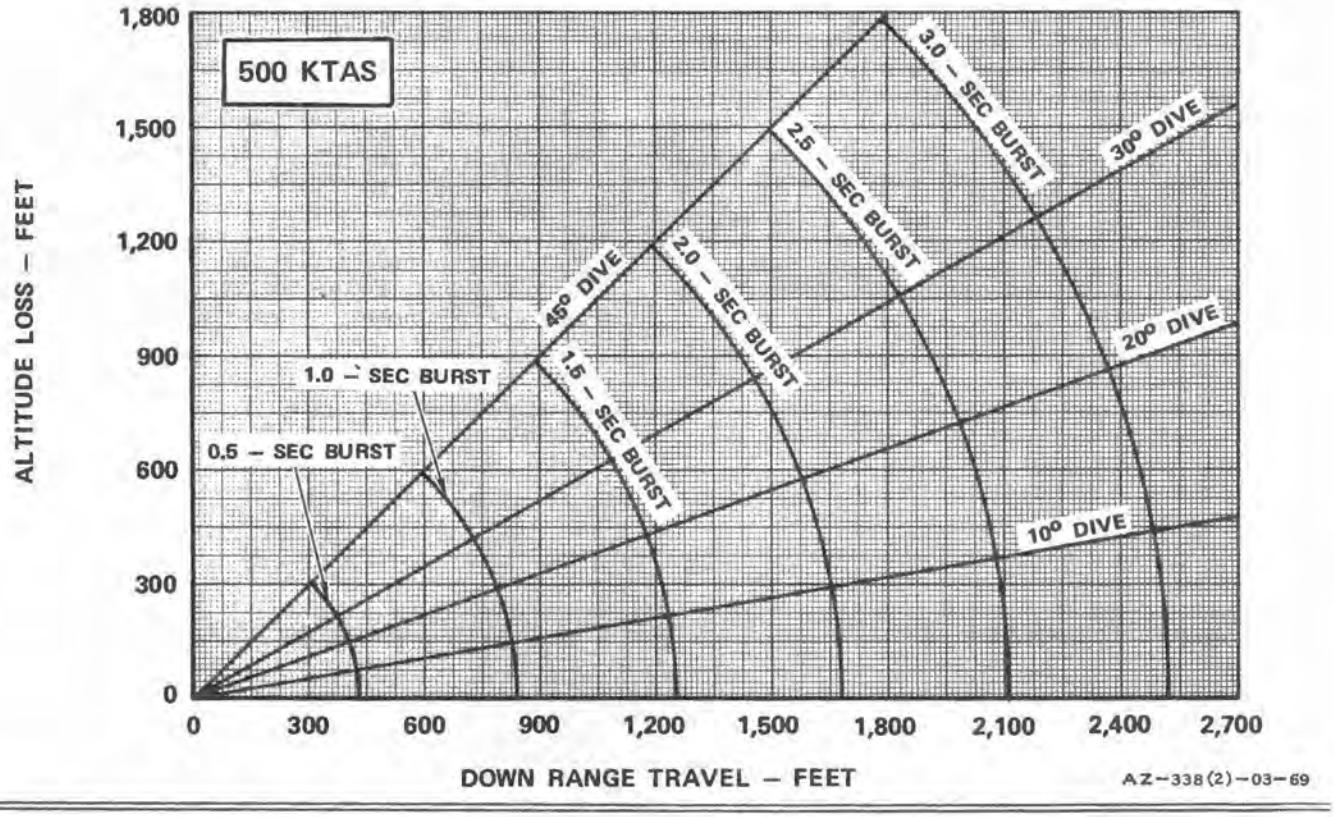


Figure 2–40 (Sheet 2)

the F-8, bomb spacing is accomplished by picking the bombs manually at periodic intervals. To perform a manual multiple release, the single/simultaneous release maneuver and switch positioning should be used with the following modifications:

a. For dive delivery, adjust the altitude of the first bomb release point upward to permit the last bomb to be released from a height that will ensure a safe recovery and escape.

b. Adjust the aim point to place the center of the bomb pattern on the target (see figure 2–41). The bomb pickle must be depressed for each single/simultaneous release in the delivery.

c. Maintain steady tracking and stable flight during the multiple release.

MER/TER AND MBR INTERVALOMETER RELEASE

WARNING

Consult the external store limitations and fuze sections in this manual to ensure the bomb/fuze combination being used is compatible with the multiple release conditions. Use minimum release intervals or greater to prevent bomb-to-bomb collisions and possible early fuze detonation.

Intervalometers incorporated in the MER/TER and MBR will allow multiple release. Figure 2–42 shows these multiple release options and intervals. These

Multiple Release

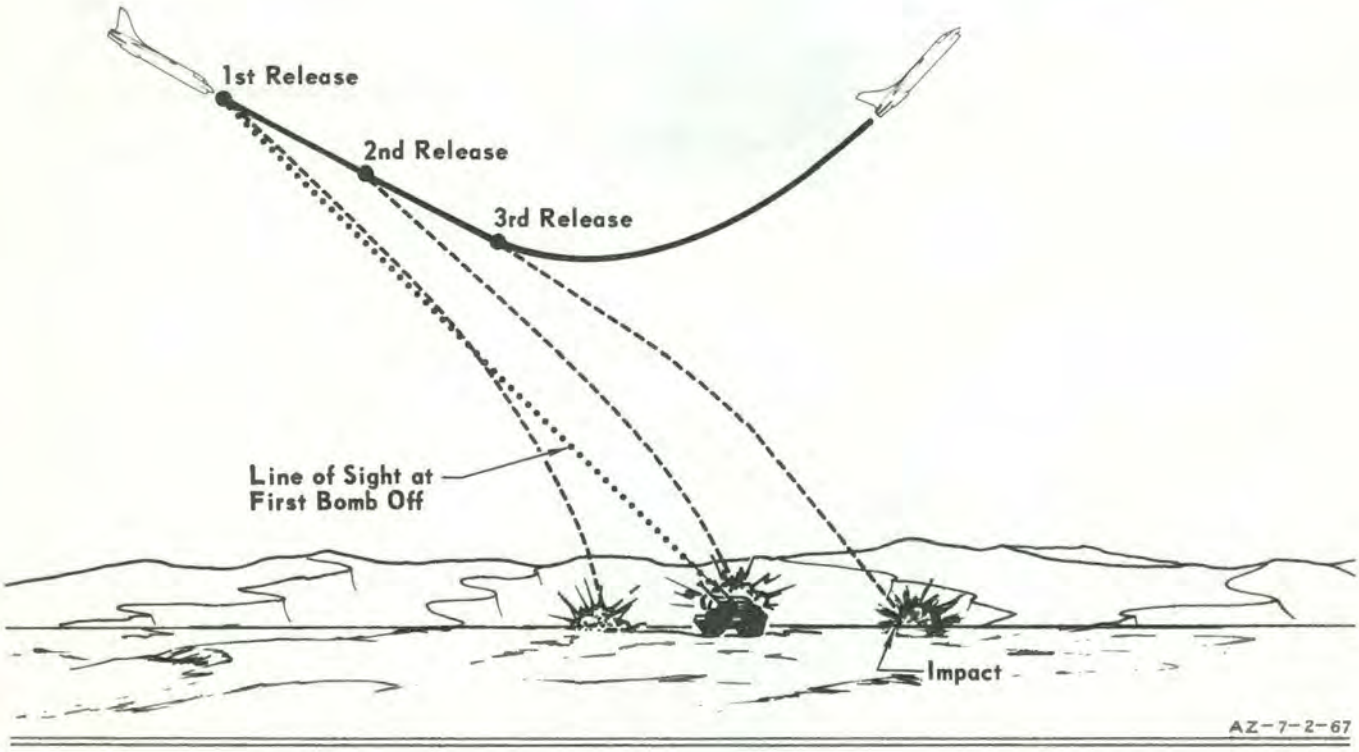


Figure 2–41

options must be preset on the ground prior to takeoff. Since these release intervals are of such short periods, close bomb impact spacing can be achieved.

Bomb Rack	*Rack Setting*	*Release Interval*
MER/TER (–505 or –521 models)	SALVO	15 to 25 milliseconds
	DUAL (MER only)	Simultaneous
MER/TER (–527 model)	AUTO RIPPLE	15 to 25 milliseconds
MBR	DUAL	Simultaneous
	.015 SEC	15 milliseconds
	.030 SEC	30 milliseconds
	.060 SEC	60 milliseconds
SIMULTANEOUS RELEASE OF SINGLE STORES FROM AERO 7A, 7A-1 EJECTOR BOMB RACK (AFTER AFC 488)		150 milliseconds

Figure 2–42. Multiple Release Options.

COORDINATED ATTACKS

When more than one aircraft are involved in an attack, careful consideration must be given to the fragmentation patterns of the other aircraft. Refer to Maximum Fragment Envelope Charts in this section for specific information.

NIGHT ATTACK

A night mission requires that consideration be given to the following:

a. Defensive maneuvers for enemy ground and air defense.

b. Coordination between all aircraft in the area regarding altitude, airspeed, and attack headings.

c. Heading and altitude from the target area in the event of disorientation or aircraft difficulties.

d. Adjusting the attack to the burn time of the flares.

e. Release and recovery altitudes. (Recovery should be above the burning flares. Occasionally a dropped flare will not ignite although its parachute is deployed. It will descend at a slightly higher rate than a burning flare.)

f. Flare effectiveness.
   1. With a low ragged overcast, fog or drizzle, flare light will be seriously reduced. Disorientation and vertigo may occur.
   2. With a high overcast or in clear weather flare light is excellent. Partial instruments will be required during dive recoveries.

See figure 2–43 for a typical night attack pattern.

Two Aircraft Night Initial Attack Pattern

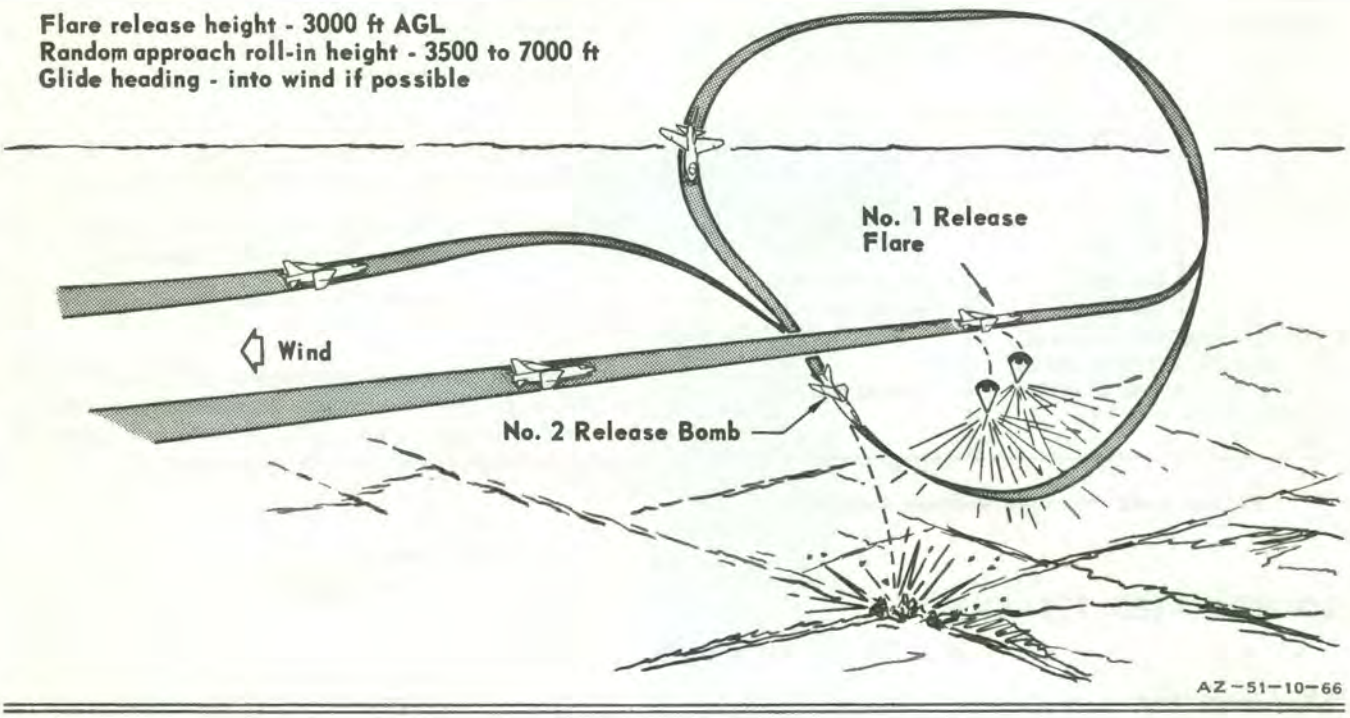


Figure 2-43

PART 4 — WEAPONS

INTRODUCTION

This part contains weapons system harmonization procedures and a detailed description and illustration of individual weapons used by the F-8 in both its air-to-air and air-to-ground missions.

WEAPON SYSTEM HARMONIZATION

Harmonization is the process of obtaining the optimum adjustment and alignment of all the aircraft's 20mm armament and fire control system components. This process includes:

a. Boresighting Guns

b. Firing in Guns

c. Gunsight Alignment

d. Alignment of Radar

e. Gunsight Camera Boresighting

HARMONIZATION SCHEDULE

a. As part of every major inspection (will not be able to fire in if a range is not available).

b. When the sight unit, guns, or gun mounts are changed or moved.

c. When the aircraft demonstrates poor harmonization.

d. Approximately every 15 firing missions.

TYPES OF BORESIGHTING

Three types of boresight used are:

a. Parallel, in which all guns are parallel to the ADL. It is acceptable for guns having a very small dispersion but results in an unacceptably large pattern for the Mk 12 Mod 0 as installed in the F-8.

b. Infinity, which is nearly the same as parallel but permits boresighting on a point of land in the distance.

c. Converging, which is the type most commonly used in the F-8. The guns are boresighted to converge at a given range. This compensates for the large dispersion pattern of the F-8 gun. Ground targets are sometimes so small that converging boresight is necessary to provide concentration of fire on the target. Normally, F-8 guns are boresighted to converge at 1,500 feet.

GUN BORESIGHT AND FIRE-IN PROCEDURES

The relationship of lines and factors involved in harmonization and the boresight template are depicted in figure 2–44. The template is aligned with the aircraft ADL and all adjustments are made relative to this point. The fixed pipper is never moved from the OSL. This allows the air-to-ground sight lead computations to be correct and makes possible the infinity boresight check. Notice that the guns are cross boresighted with the upper and lower guns on each side converging on the same cross. Barrel whip and bullet bounce will move the MPI laterally back across the centerline seven inches. This aim point was obtained through trial and error only but will cause bullet convergence laterally at 1,500 feet. If the center of the MPI exceeds 21.3 inches for the upper guns and 20.6 inches for the lower guns from the center line, the projectiles are not converging and the GBL must be readjusted. The vertical distance between the OSL and GBL's is also decreased to correct for parallax. This has been done by raising the GBL's two thirds of the distance (27 inches) for the 1,000-foot template. This will converge the OSL and the GBL's vertically at 1,500 feet.

Gun Boresight and Fire-in Procedures are as Follows:

a. Place aircraft on pad at boresight range, aligned toward target.

b. Jack aircraft at three points sufficient to take weight off of landing gear (strut starts extending). Level aircraft laterally with leveling tool across canopy rails.

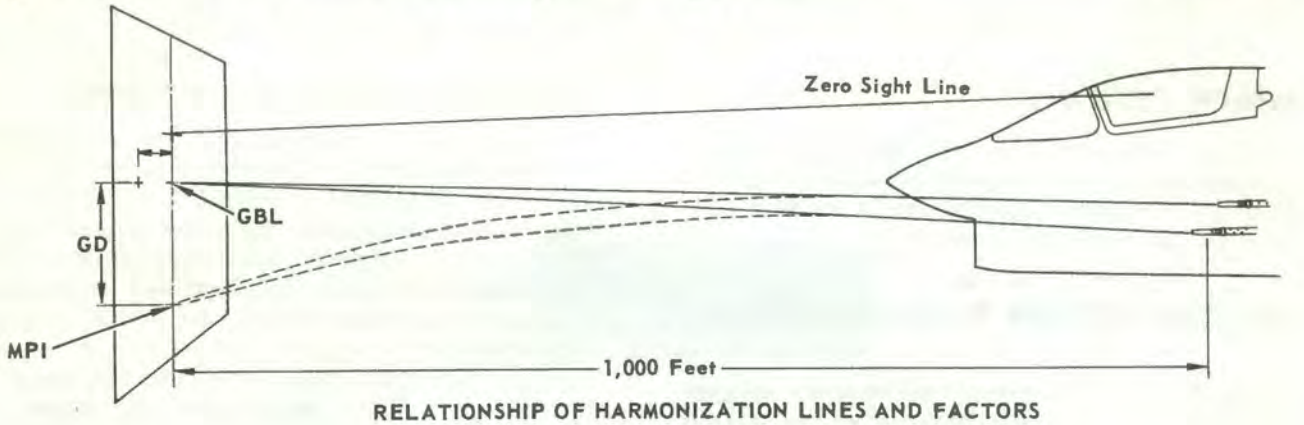
c. Install ADL boresight telescope on left side of the fuselage for a one degree depression below the FRL.

d. Position the boresight target (figure 2–44) 1,000 feet down the range in such a manner that the ADL cross on the target is aligned with the cross hairs in the ADL boresight telescope (boresight kit CV15-206126-87). The nose wheel may be adjusted for azimuth corrections. The nose of the aircraft may be elevated slightly with the nose jack to facilitate the alignment. Ensure that the target banner is vertical by using a plumb bob.

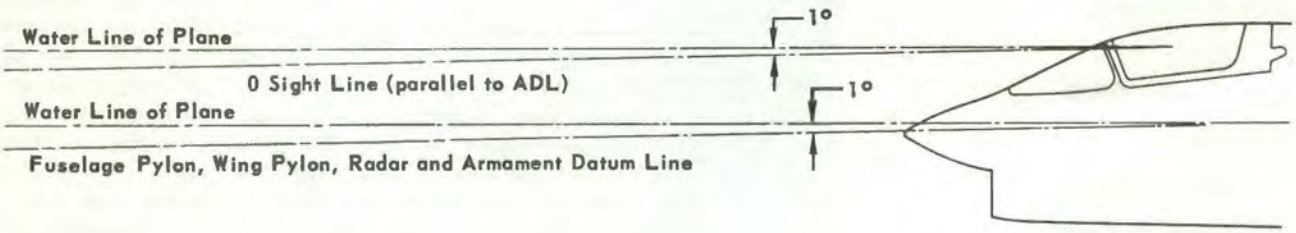
e. Tie the aircraft down securely in at least three points. The combination of jacks and tie downs will prevent the aircraft from shifting position during fire-in.

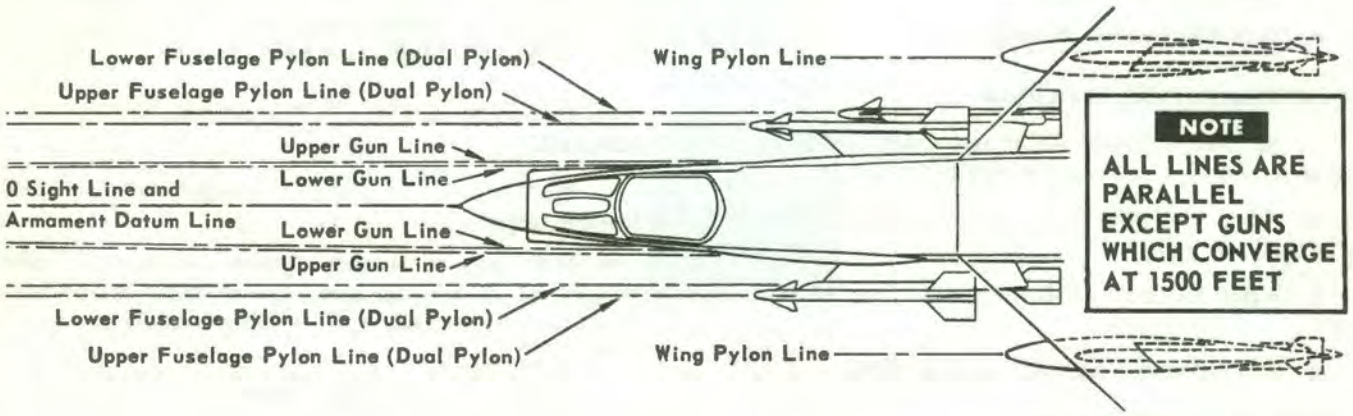
f. Install a boresight tool (Mk 3 Mod 0) in each gun and align the gun so that the cross hairs of the tool

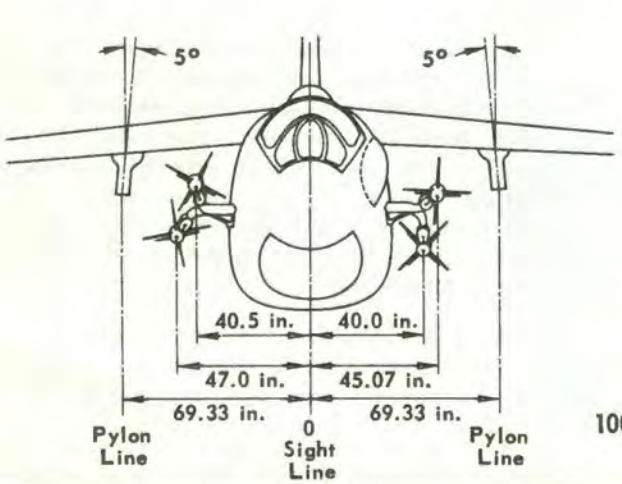
Reference Lines and Boresight Target

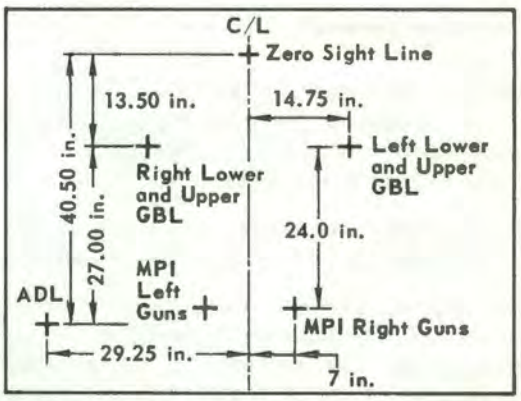


RELATIONSHIP OF HARMONIZATION LINES AND FACTORS









1000 FEET BORESIGHT TARGET FOR 1500 FEET CONVERGENCE USING ADL 1° BELOW FRL

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Figure 2-44

coincide with the GBL cross on the opposite side of the target centerline (i.e., cross the guns). Align the guns by adjusting the double eccentrics located in the forward gun mount.

g. Load each gun with 15 rounds of TP ammunition. The ammunition should be painted a different color for each gun to mark that particular gun's pattern. Guns may be fired in pairs or quads but never fire one gun without firing the corresponding gun on the opposite side to approximate stresses and vibrations encountered in aerial gunnery.

h. Observing all range safety precautions, fire-in the guns. Each gun must produce 15 rounds of uninterrupted fire. If a gun stops before fire-out, it must be examined, repaired, and reloaded with 15 rounds until it will produce 15 rounds of uninterrupted fire. This requirement will solve most gun problems prior to the first firing mission and will greatly improve gun performance and increase fire-out rates.

i. For each gun, 13 out of 15 rounds must impact an area 5 feet 10 inches square and having as its center a point seven inches from the centerline and approximately 24 inches below the GBL crosses. If an individual gun does not meet this requirement, it must be re-boresighted, moving its GBL off the cross to correct for its error in MPI, and re-fired until it does meet the requirements.

j. A detailed record of the fire-in data should be made to allow the aircraft to be boresighted when a fire-in range is not available.

GUNSIGHT ALIGNMENT PROCEDURE

a. Connect electrical power and place the power and fixed switches on the Mk 44 Mod 0 control box in ON.

b. Align the vertical ladder image with the vertical reference line (center line) on the boresight target.

c. Align the center (pipper) of the fixed reticle image with the zero sight line cross on the boresight target. Use the elevation adjustment for vertical corrections and the azimuth adjustment for lateral corrections. Lock the adjustments in place.

Note

This is a most critical procedure if sight alignment is to be maintained.

d. Place the power and fixed switches on the Mk 44 Mod 0 control box in OFF and disconnect electrical power.

RADAR ALIGNMENT PROCEDURE

Refer to NAVAIR 0-45HHD-2-6.1 for this alignment procedure.

GUNSIGHT CAMERA BORESIGHT PROCEDURE

Refer to NAVAIR 01-45HHD-2-6 for this boresight procedure.

GENERAL CHARTS AND TABLES

A series of charts and tables applicable to all weapons and/or delivery modes is provided to complete mission planning. These charts and tables are described in the following paragraphs.

AIRSPEED CONVERSION

The airspeed conversion chart (figure 2–45) is used to relate calibrated airspeed, true airspeed and true Mach number.

FUSELAGE ANGLE OF ATTACK

The fuselage angle of attack chart (figure 2–46) is required for computing mil lead. The fuselage angle of attack minus 17 mils (the armament datum line or zero sight line is one degree below the fuselage reference line) is added to the trajectory drop of a bomb to determine the mil lead. Parameters required for using the chart must include indicated airspeed, aircraft gross weight, dive angle and release altitude.

DIVE RECOVERY

These charts (figure 2–47) can be used to determine altitude loss during dive recovery when 4g or 6g pullouts are made. The pullout is based on a 4g in 2 seconds rate.

AIRCRAFT DOWNRANGE TRAVEL AND ALTITUDE LOSS

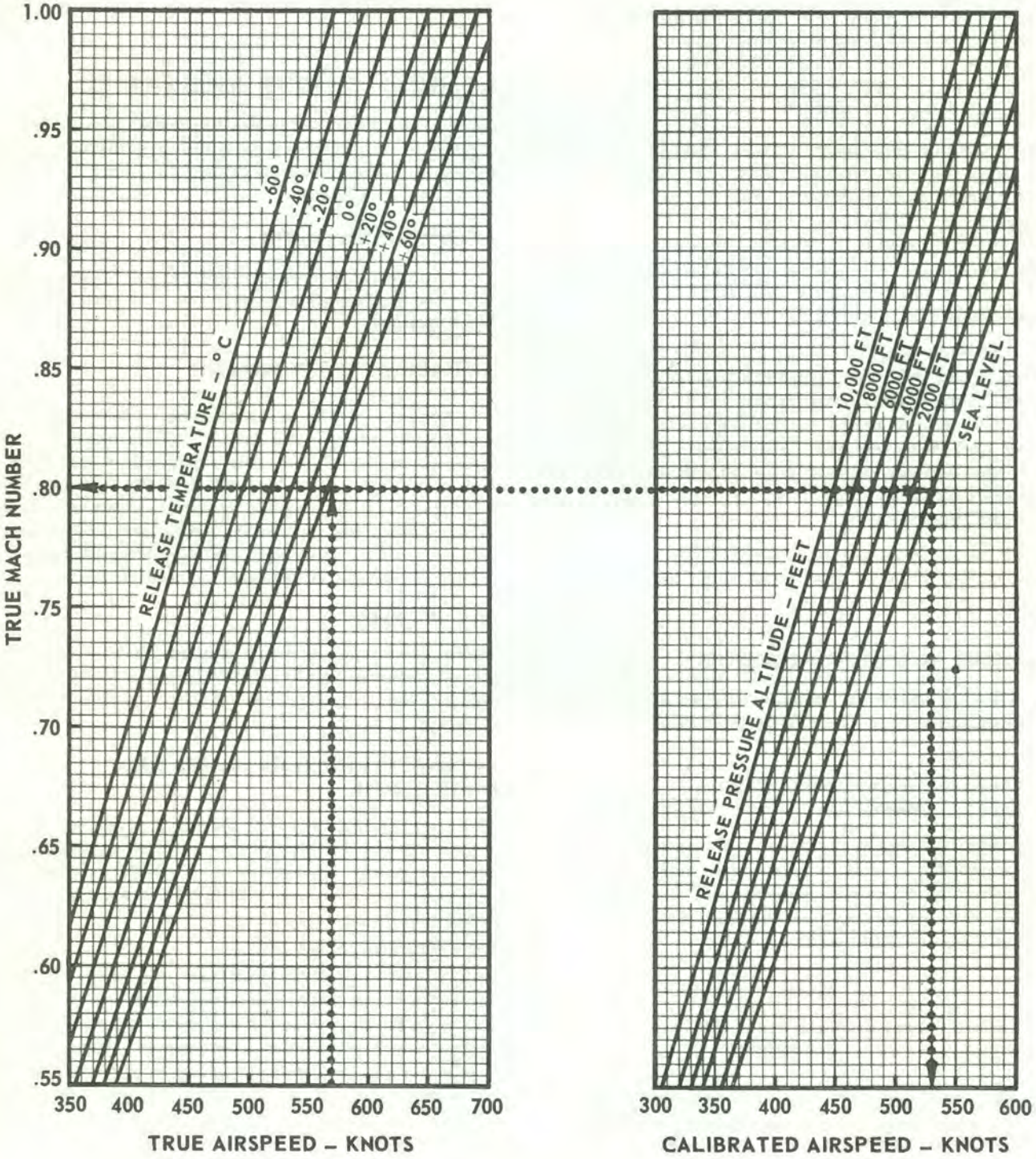
These charts (figure 2–48) are used to determine the loss of altitude and the distance covered on the ground between bomb releases of a multiple release. The charts are based on the MER/TER release interval for multiple releases.

ICAO STANDARD DAY DATA

This chart (figure 2–49) provides the ICAO standard temperature for each 1,000-foot level up to 15,000 feet. Each bomb mil lead chart contains mil lead correction data for variance from standard temperatures at release altitudes. By comparing temperature given for release altitude at prestrike briefing with the standard temperature, a mil lead correction can be determined.

Airspeed Conversion

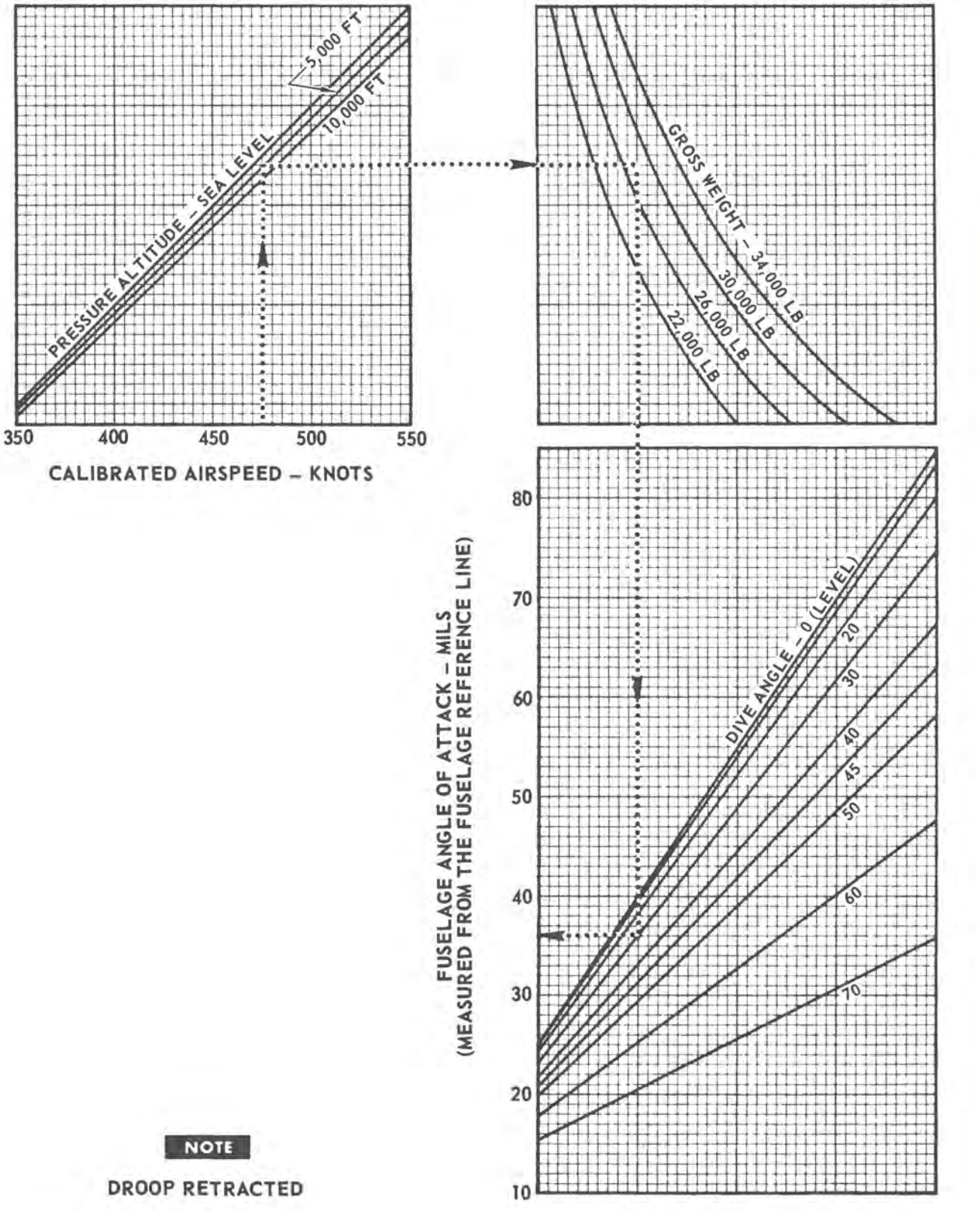
TAS/CAS/TRUE MACH



AZ-138-11-66

Figure 2–45

Fuselage Angle of Attack



NOTE

DROOP RETRACTED

AZ-155-12-66

Figure 2–46

Dive Recovery Chart

4g PULLOUT

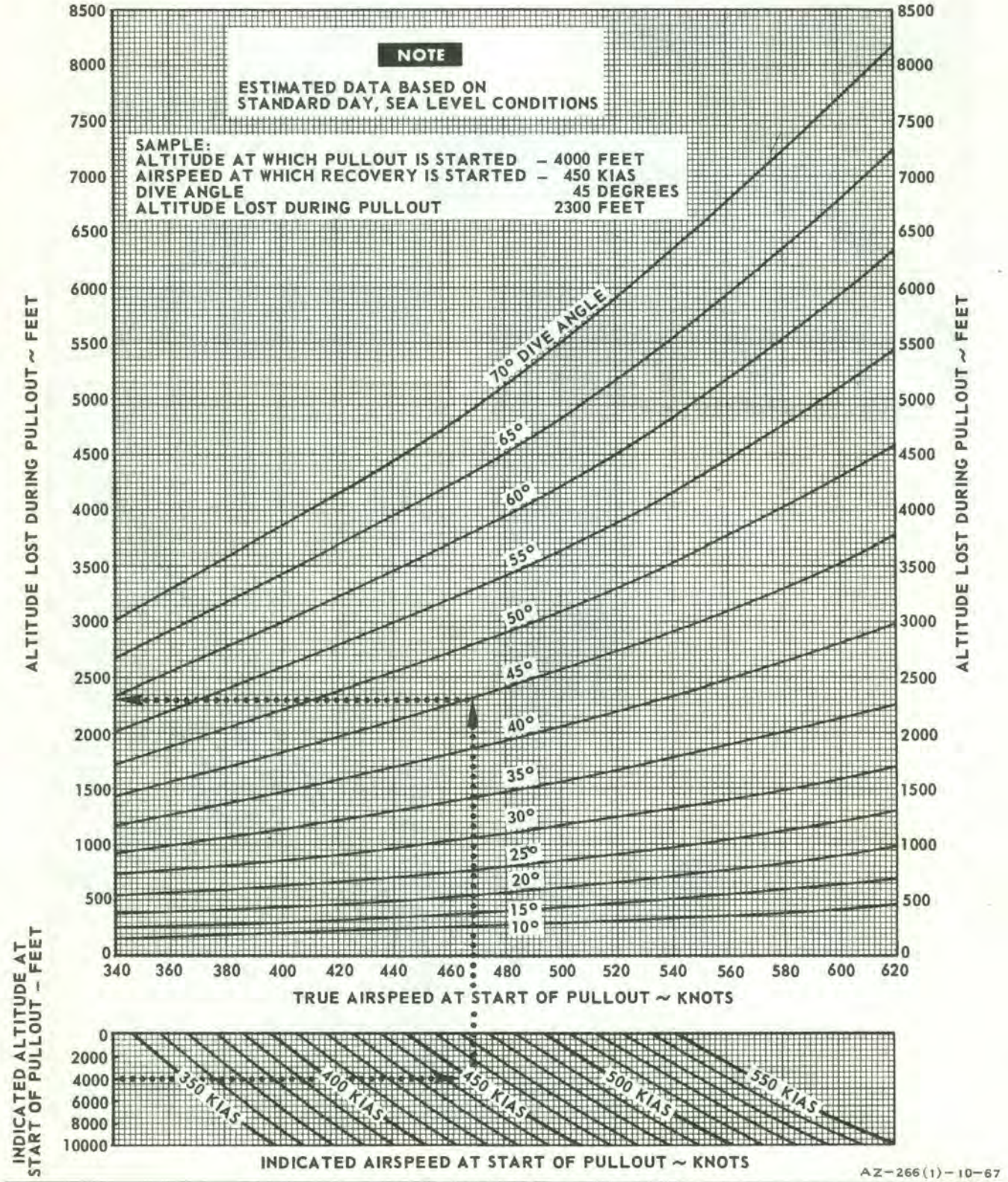
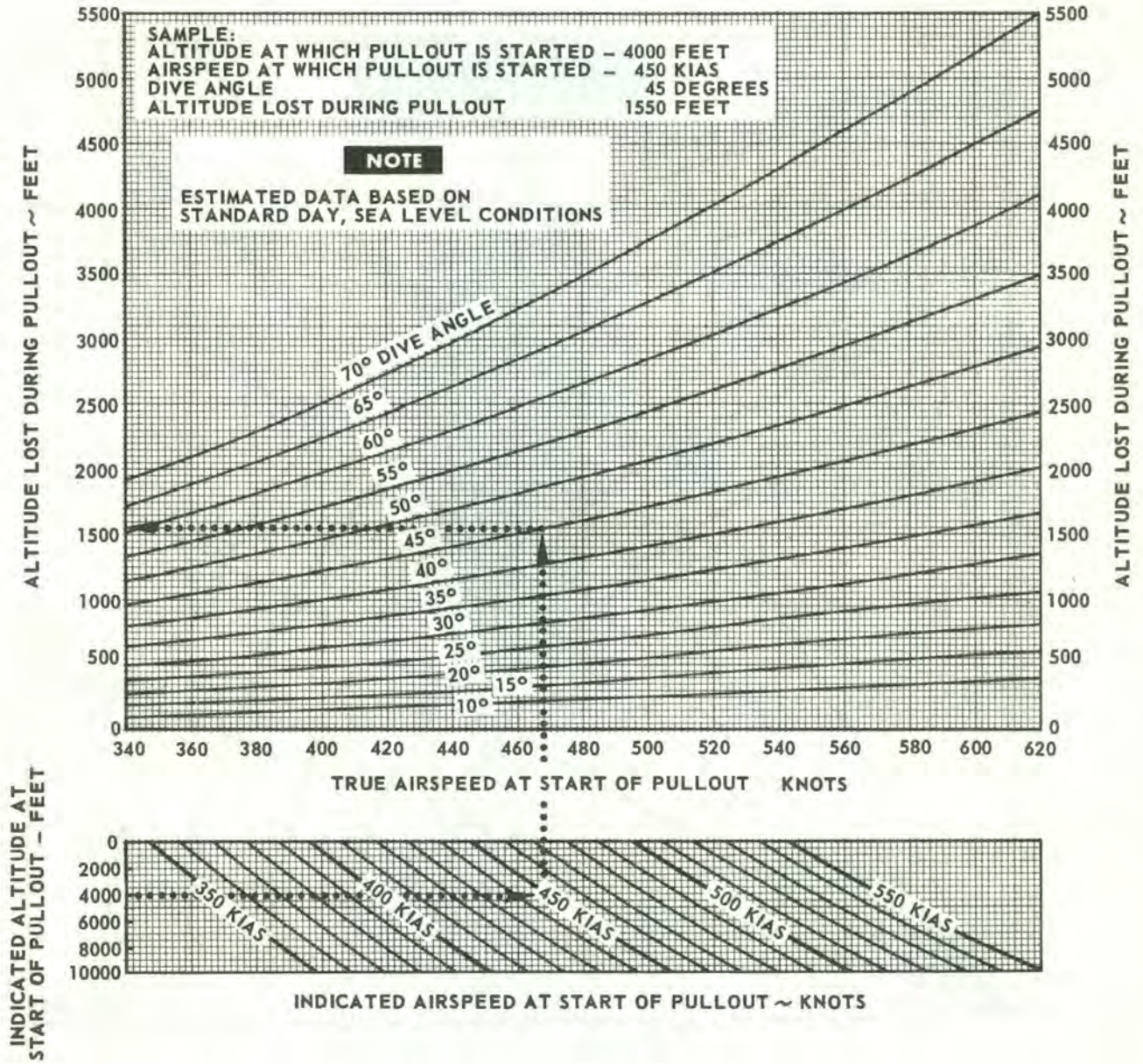


Figure 2–47 (Sheet 1)

Dive Recovery Chart

6g PULLOUT

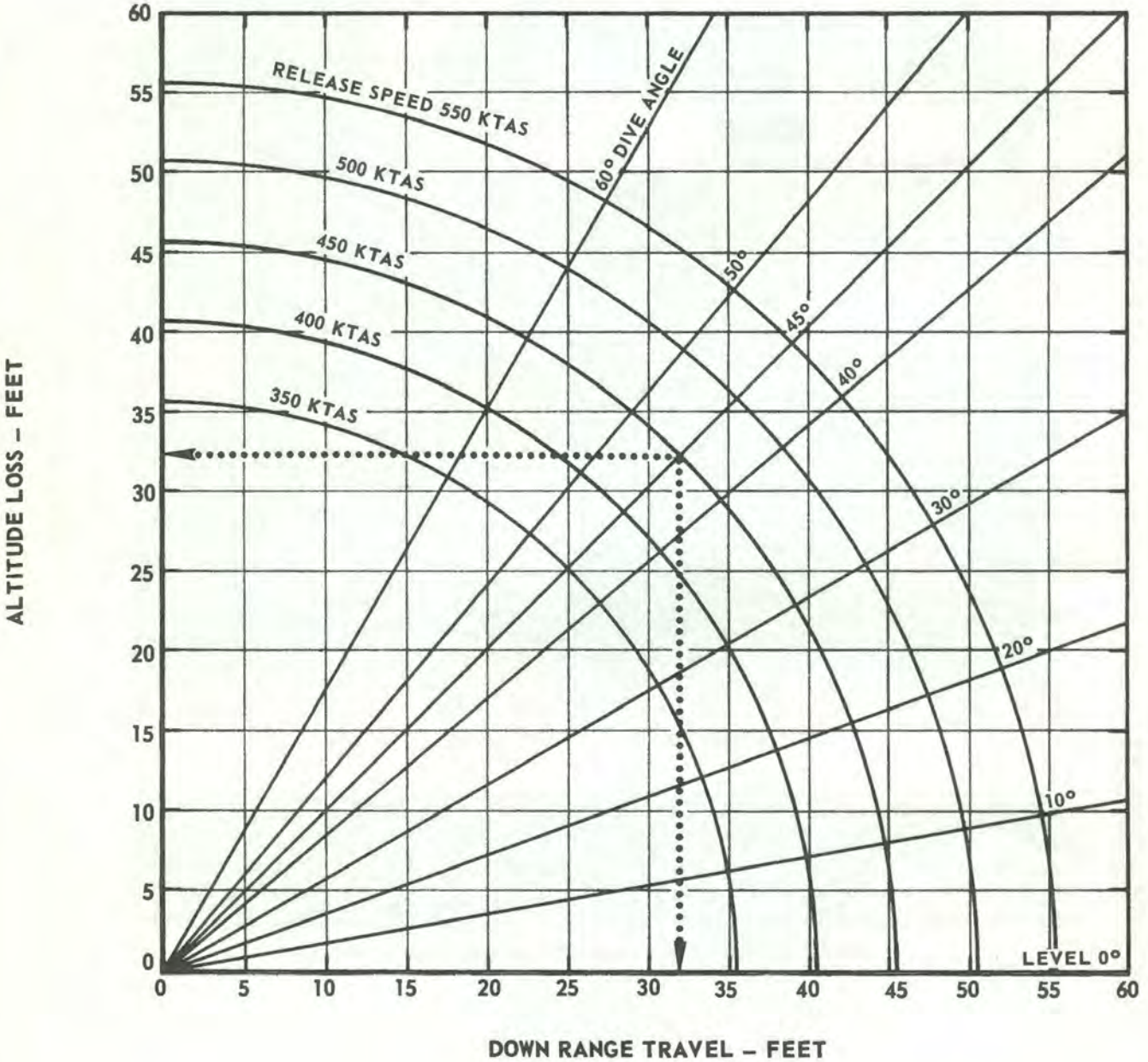


63763-139(2)-11-66

Figure 2–47 (Sheet 2)

Aircraft Down Range Travel and Altitude Loss

A RELEASE INTERVAL OF 0.06 SEC

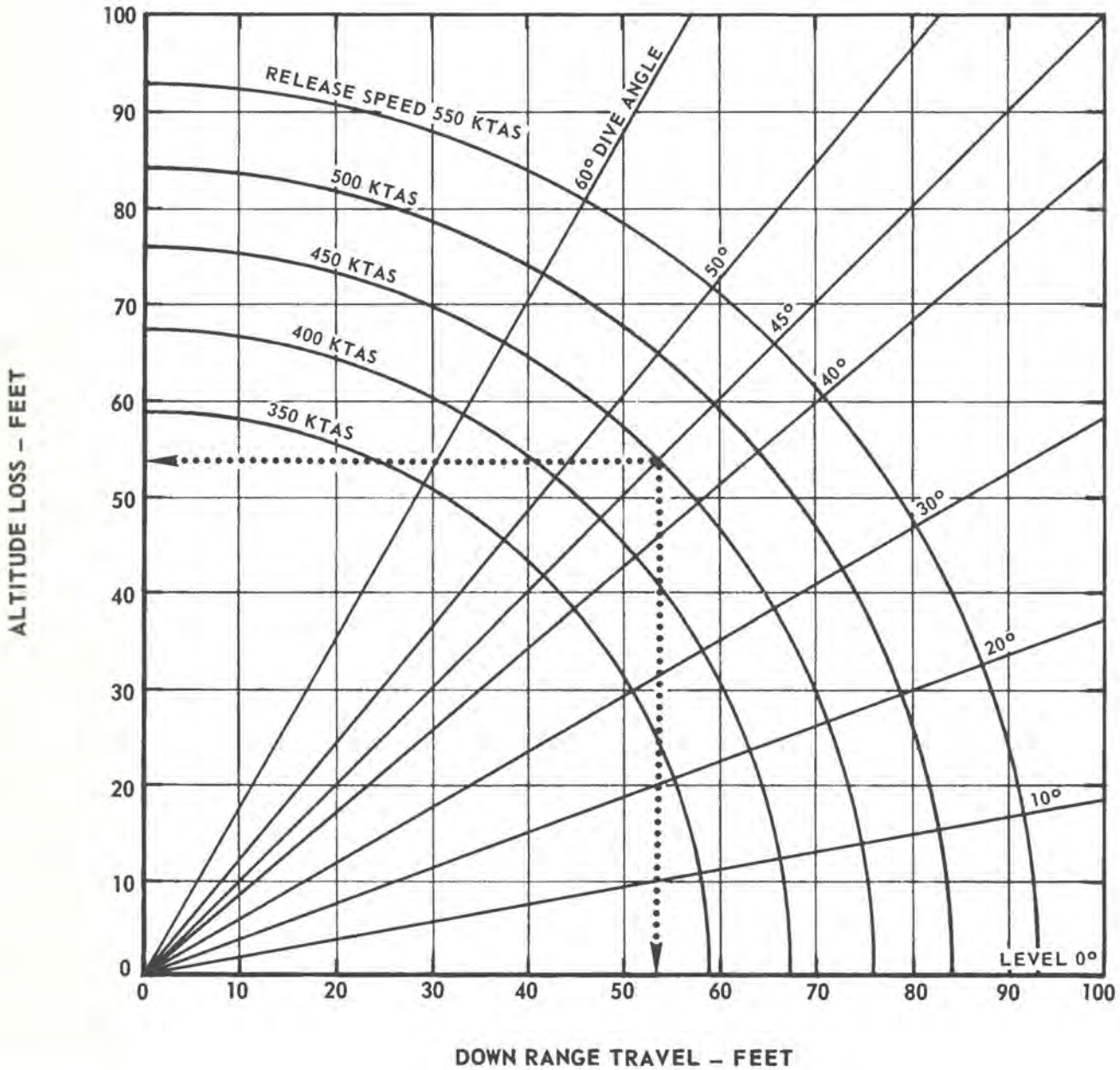


AZ-156(1)-12-66

Figure 2–48 (Sheet 1)

Aircraft Down Range Travel and Altitude Loss

A RELEASE INTERVAL OF 0.10 SEC

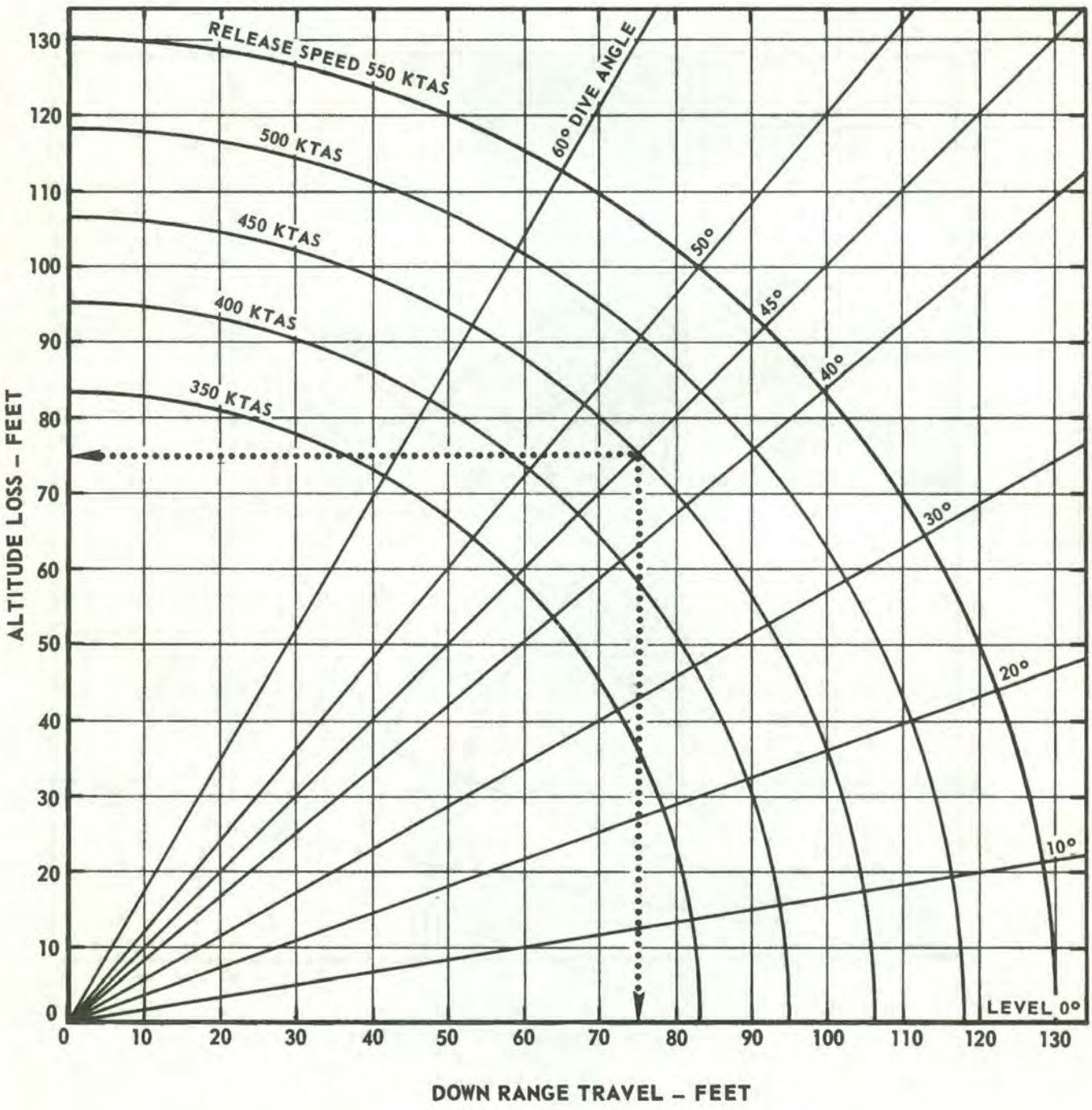


AZ-156(2)-12-66

Figure 2–48 (Sheet 2)

Aircraft Down Range Travel and Altitude Loss

A RELEASE INTERVAL OF 0.14 SEC



AZ-156(3)-12-66

Figure 2–48 (Sheet 3)

ICAO Standard Day Data

STANDARD SL CONDITIONS: TEMPERATURE – 15°C (59°F) PRESSURE – 29.921 IN. Hg; 2116.216 LB/SQ FT SPEED OF SOUND – 1116.89 FT/SEC; 661.7 KNOTS				
ALTITUDE FEET	STANDARD TEMPERATURE		SPEED OF SOUND KNOTS	PRESSURE IN. Hg
	°C	°F		
0	15.000	59.000	661.7	29.921
1,000	13.019	55.434	659.5	28.856
2,000	11.038	51.868	657.2	27.821
3,000	9.056	48.302	654.9	26.817
4,000	7.076	44.735	652.6	25.842
5,000	5.094	41.169	650.3	24.896
6,000	3.113	37.603	648.7	23.978
7,000	1.132	34.037	645.6	23.088
8,000	– 0.850	30.471	643.3	22.225
9,000	– 2.831	26.905	640.9	21.388
10,000	– 4.812	23.338	638.6	20.577
11,000	– 6.793	19.772	636.2	19.791
12,000	– 8.774	16.206	633.9	19.029
13,000	– 10.756	12.640	631.5	18.292
14,000	– 12.737	9.074	629.0	17.577
15,000	– 14.718	5.508	626.6	16.886

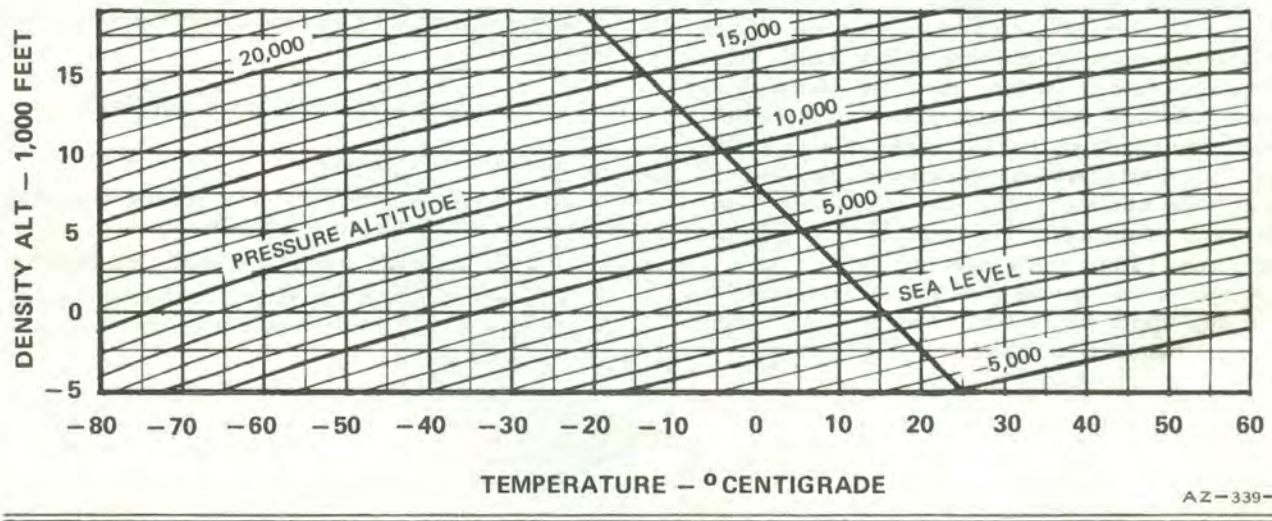


Figure 2–49 (U)

WEAPON DESCRIPTION AND DELIVERY DATA

CAUTION

Weapons illustrations do not constitute authority for loading or carriage. This information is presented in figure 2–2, External Stores Limitations.

Each weapon carried by the F-8 is illustrated along with some typical loading configurations for each wing and fuselage station. Weapon firing or bomb dropping procedures are provided along with a check list for jettisoning stores.

Delivery data for each type of weapon is provided in a series of charts and tables following the weapons illustration.

MIL LEAD CHARTS

WARNING

Variations from the following assumptions and the release restrictions specified in the mil lead charts may significantly change the release altitudes required to avoid weapon fragments. The weapons may not be cleared for release at all delivery conditions specified in the mil lead charts. See figure 2–2 for weapon release limitations.

Mil lead charts are given for single bomb releases from a specified rack. These charts provide the mil lead for various dive angles, release altitudes (AGL), release airspeeds and an aircraft gross weight of 27,000 pounds. Time of fall (TOF) curves are plotted on the graphs for use in selecting release heights that will provide adequate arming time for the type of fuze used. The mil lead values given in the charts include trajectory drop, aircraft angle of attack and the effect of ejection velocity imparted to the weapon by the rack for which the charts are applicable. Parallax has been neglected. Since most of the weapons may be released from more than one type of rack, a table of corrections to mil lead for various racks is given in the upper left corner of each chart. These are average corrections which can be expected to introduce inaccuracies as large as ±5 mils in extreme cases. Since ICAO standard day temperatures are used in computing the mil lead charts, an additional set of corrections is given on each chart. The corrections are for 10°C and 30°C variations from the ICAO standard day temperature *at the release altitude* of the particular weapon. For an increase from standard, add the correction, for a decrease from standard, subtract the correction. See figure 2–49 to determine standard temperatures.

The mil lead charts are terminated at the required release altitudes to provide a specified terrain clearance and avoidance of all predictable fragments projected from the weapon at detonation. The chart area encompassing unsafe release conditions is shaded and designated as "release unsafe". Generally, the release restrictions are due to fragment hazards for dive angles less than 45 degrees and terrain clearance requirements for dive angles greater than 45 degrees. These restrictions are predicated on the following:

a. An assumed straight and level, constant velocity recovery for level delivery, and a 4g pullup to 15 degrees for dive delivery.

b. A 2-second g buildup time for dive recovery.

c. Terrain clearance requirements as follows:

Dive Angle (deg)	*Terrain Clearance (ft)**
0	100
10	200
20	300
30	500
40,45	700
50,60	1000

*Difference between burst altitude and minimum aircraft altitude in pull-out.

d. Instantaneous weapon detonation at ground level (zero altitude).

The release altitude restrictions are also applicable to:

a. Salvo weapon delivery.

b. Ripple weapon delivery. The release restriction should be based on the last bomb released.

c. Delayed bomb detonations, assuming no ricochet.

d. VT fuzed air burst delivery. In this case, the zero altitude on the mil lead chart should be considered as the burst altitude.

MAXIMUM FRAGMENT ENVELOPE CHARTS

Maximum fragment envelope charts, showing fragment position relative to the weapon burst point as a function of time, are given for use in determining safe release intervals between aircraft for multiple aircraft attacks. These fragmentation charts are based on the assumption that the most hazardous fragment (ie, the heaviest fragment with the maximum velocity) can be projected from the burst point at any angle irrespective of weapon delivery conditions. Similar charts for rockets are given as a function of impact angle where the impact angle is approximately equal to the launch angle. The rocket envelopes may be rotated for consideration of launch angles other than those given.

A conservative estimate of a safe release interval may be obtained from the charts by using the following procedure.

Note

This procedure is valid only if both the leading and trailing aircraft deliver their weapons at the same airspeed, dive angle, and direction relative to the target.

Compute the trailing aircraft's recovery altitude. If this recovery altitude is greater than the maximum ordinate of the leading aircraft's weapon fragments (as given in the maximum fragment envelope chart), any interval between aircraft may be used without endangering the trailing aircraft.

If the trailing aircraft's recovery altitude is less than the maximum ordinate of the leading aircraft's weapon fragments, the safe release interval is the sum of the weapon's time of flight and the fragment's time of flight from burst through maximum ordinate to the recovery altitude of the trailing aircraft.

SAFE RELEASE INTERVAL — SAMPLE CALCULATION

Weapon: MARK 81 Conical Fin
Release Conditions: 20 degrees
550 KIAS
2500 feet

Trailing Aircraft: Recovery altitude is the aircraft release altitude minus altitude loss (6g pullout)
Recovery altitude = 2,500-700 feet
= 1,800 feet

Recovery altitude is less than the maximum ordinate of the MARK 81 GPLD fragment envelope from the leading aircraft; therefore, safe release interval is the weapon's time of flight plus fragment's time of flight from burst through maximum ordinate to the recovery altitude of the trailing aircraft.

Weapon time of flight = 6 seconds
Fragment time = approximately 18 seconds (value obtained from MARK 81 GPLD maximum fragment envelope)
Safe release interval = 6 seconds + 18 seconds
= 24 seconds

TABULATED DELIVERY DATA

Tabulated delivery data providing trajectory drop in mils, weapon fall in seconds, horizontal range of the weapon in feet, and slant range in feet are available and can be obtained from NAVAIR 11-5T-55, Tactical Manual Ballistic Tables. These tables are based on zero ejection velocity. To determine the correct mil lead, refer to the multiplier chart to determine correction factor for the bomb rack to be used.

TESTED DELIVERY DATA TABLES

The tested delivery data tables are the results of actual tests. The tested information may vary slightly from the data on the mil lead charts. These minor differences are a result of the assumptions made above in computing the mil lead charts.

Note

The tested delivery data is based on a 0.001 probability of fragmentation damage whereas the mil lead charts are based on zero probability of fragmentation damage. Consequently, release altitudes for the tested data may be in the release unsafe area of the corresponding mil lead chart. (Each mil lead chart depicts in tabular form the probability of fragmentation damage for 0.000, 0.001 and 0.010.)

MIL LEAD COMPUTATION FOR A SINGLE BOMB RELEASE

The mil lead is obtained by adding algebraically the trajectory drop of the weapon in mils to the fuselage angle of attack minus 17 mils (to correct for the difference between the armament datum line and the fuselage reference line) and the correction for parallax in mils. The parallax correction for the F-8 aircraft is

small and may be neglected. Hence, the equation for computing mil lead for bombs is

$$ML = D + AA$$

where

ML	is mil lead
D	is trajectory drop in mils
AA	is angle of attack of Armament Datum Line in mils

The angle of attack for the desired delivery conditions and standard aircraft delivery weight (27,000 pounds) may be obtained from figure 2–46.

SAMPLE PROBLEM

Release Conditions: MARK 81/Unretarded/Snakeye I, 30-degree Dive, 500 KIAS, 4,000-foot AGL, 25,000-pound, Aero 7A Rack

Angle of attack (figure 2–46) minus 17 mils	– 13 mils
Trajectory drop (NWL Ballistic Table)	119 mils
Ejection velocity correction (0.2 obtained from the multiplier table (figure 2–49) multiplied by correction from NWL Ballistic Table)	2 mils
Mil lead	134 mils

MIL LEAD COMPUTATION FOR ROCKET FIRING

The mil lead computation for unguided rockets differs from the mil lead computation for bombs since the attitude of the rocket at release (or firing) must be considered due to the fact that rockets tend to align with the airstream. The general equation for computing mil lead for rockets is

$$ML = D + f(AA + L) - L + B + P$$

where

ML	is mil lead
D	is trajectory drop in mils
f	is launch factor, dimensionless
AA	is angle of attack of Armament Datum Line (ADL) in mils (angle of attack of fuselage reference line minus 17 mils)
L	is launcher angle in mils (negative when the launcher line is below the ADL)
B	is the angle between the ADL and the zero sight line in mils (negative when the zero sight line is below the ADL)
P	is parallax correction in mils

The above equation can be simplified considerably for use with F-8 aircraft with no significant loss in accuracy. The launcher angle (L) and the angle between the ADL and the zero sight line (B) are zero for F-8 aircraft. The parallax correction for F-8 aircraft is small and may be neglected. Therefore the mil lead equation reduces to the following:

$$ML = D + (f)(AA)$$

The trajectory drop data (D) and launch factors (f) for the 2.75-inch FFAR and 5.0-inch Zuni rockets may be obtained from Ballistic Ordnance Pamphlets 2532 and 2682 respectively, or from ballistic tables published by the Naval Weapons Laboratory, Dahlgren, Virginia. The angle of attack of the ADL may be obtained by subtracting 17 mils from the fuselage reference line angle of attack (figure 2–46).

In order to correct the mil lead for 2.75-inch FFAR and 5.0-inch Zuni rockets for an increase in aircraft angle of attack, 0.8 mil should be added for each 1.0 mil increase in aircraft angle of attack. This is an approximation and is equivalent to using an average launch factor for all airspeeds. This may introduce error as large as ±4 mils for large increases in angle of attack.

SAMPLE PROBLEM

Release Conditions:

Dive angle	20 degrees
Indicated airspeed at release	450 knots
Release altitude (AGL)	3,000 feet
Aircraft gross weight	30,000 pounds
Rocket	2.75 inch FFAR
Launcher	LAU-3/A

1. Obtain trajectory drop (D) from OP 2532	31 mils
2. Obtain the angle of attack of ADL (AA) from figure 2–46	
3. Obtain the launch factor for the 2.75-inch FFAR from OP 2532	0.834
4. Multiply item 2 by item 3	22 mils
5. Add items 1 and 4 for mil lead	53 mils

JETTISONING

F-8 MODELS: H, J, K, L* AND C AFTER AFC 497

There are two jettison circuits, salvo and selective. The salvo circuit permits immediate jettisoning of all stores

*The F-8L has provisions for installing ventral fins and a wing stores system. The flight characteristics and flight limitations necessary to operate with these features have not been published. Wing stores shall not be carried nor ventral fins installed without specific authority from Naval Air Systems Command.

(except fuselage-mounted Zuni rockets) through the movement of a single switch. The selective circuit allows for the selection and jettisoning of individual stations (except fuselage Zuni stations) when time and circumstances are more permitting. (Note that it is impossible to jettison Zuni's from fuselage pylons using either of these circuits. If it becomes necessary to get rid of Zuni rockets, they can only be fired armed using the normal firing procedure. The empty Zuni packs must then be retained, for they are nonjettisonable.) Stores jettisoned by these circuits separate in an unarmed and unguided condition. Electrical power for salvo or selective jettisoning is supplied by the emergency dc bus. This permits jettisoning on main generator power or on emergency electrical power supplied by the ram air turbine with the emergency generator switch in ON or LAND. The master armament switch need not be placed in ON for salvo or selective jettisoning. See figure 2–49A for jettisoning controls and their functions.

F-8 MODELS: A, B, AND C WITHOUT AFC 497

These aircraft are provided with only one jettisoning circuit as only fuselage external stores are authorized for carriage. It is impossible to jettison Zuni rockets from fuselage pylons using this circuit. Zuni's can only be fired armed using normal firing procedures. The empty Zuni packs are nonjettisonable. The missile jettisoning switch fires the Sidewinder missile in an unguided and unarmed state by applying firing voltage directly to the rocket motor squib. Electrical power for jettisoning is provided by the primary dc bus. See figure 2–49A for jettisoning controls and their functions.

See figures 2–50 through 2–115 for weapons illustrations, fragmentation, mil lead, and tested delivery charts and tables.

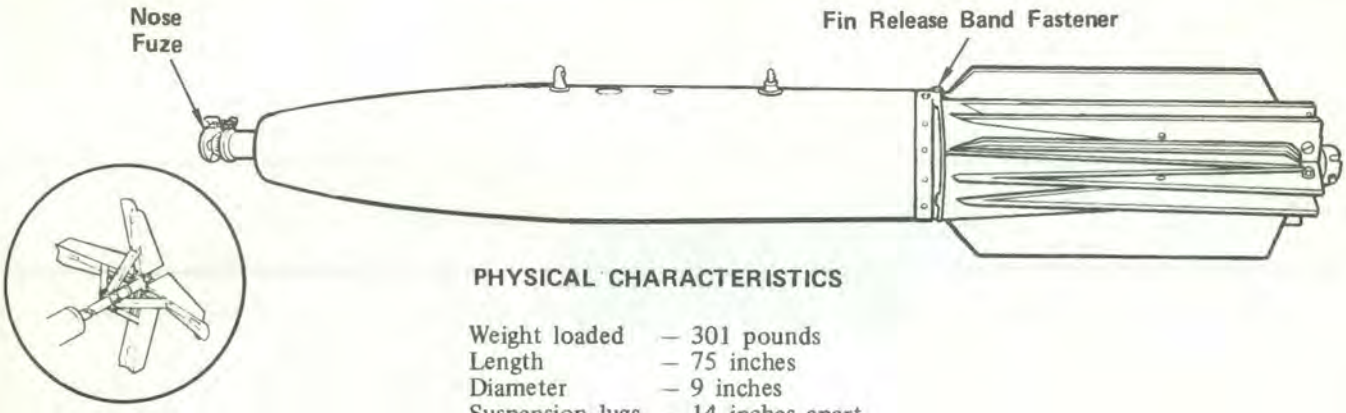
Jettisoning Controls and Functions

AIRCRAFT MODEL/ SWITCH	SWITCH LOCATION	FUNCTION
F-8 Models: A/B Missile jettisoning switch	F-8A – Top of instrument panel F-8B – Armament panel	LH MISSILE JETTISON – launches left missile in unarmed and unguided condition (landing gear handle in WHEELS UP). RH MISSILE JETTISON – launches right missile in unarmed and unguided condition (landing gear handle in WHEELS UP). NORMAL – disconnects jettisoning circuit.
F-8 Models: H, J, K and C after AFC 497 Selective jettison switch	All models – armament panel	ON – jettisons stores selected by armament selector switch with landing gear handle in the WHLS UP* position. With a wing pylon selected, jettisons all stores attached to the AERO 7A-1 ejector rack, including any multiple racks or launchers. MER/TER STORES – placing the switch in this position with the landing gear handle in WHLS UP* and the pylon MER/TER mode switch in RKT position, permits one rocket pack to be jettisoned from the MER or TER of the selected wing pylon with each depression of the stores release button. With both triple-multiple rack fire-mode switches in DUAL, simultaneous jettisoning from the left and right MER/TER occurs. OFF – deenergizes select jettison circuit.
Salvo jettison switch	All models – Left longeron panel	LW/F-U – jettisons stores being carried on left wing pylon and upper fuselage pylons with landing gear handle in the WHLS UP* position. RW/F-L – jettisons stores being carried on right wing pylon and lower fuselage pylons with landing gear handle in the WHLS UP* position. *Placarded WHEELS UP for F-8C and F-8K
F-8 Model: C before AFC 497 Missile jettisoning switch	Armament panel	UP – jettisons left and right upper missile simultaneously in an unarmed and unguided condition with landing gear handle in WHEELS UP position. LWR – jettisons left and right lower missiles simultaneously in an unarmed and unguided condition with landing gear handle in WHEELS UP position. Switch must be in LWR to jettison missile from single pylons.
F-8 Model: L Selective jettison switch Salvo jettison switch	Armament panel Left longeron panel	ON – jettisons stores selected by armament selector switch with landing gear handle in the WHEELS UP position. OFF – deenergizes select jettison circuit. LEFT WING/FUS – jettisons stores being carried on left fuselage pylons with landing gear handle in the WHEELS UP position. RIGHT WING/FUS – jettisons stores being carried on right fuselage pylons with landing gear handle in the WHEELS UP position.

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Figure 2–49A

MK 81 GP Bomb Snakeye I



PHYSICAL CHARACTERISTICS

Weight loaded — 301 pounds
Length — 75 inches
Diameter — 9 inches
Suspension lugs — 14 inches apart

DESCRIPTION

The Mk 81 Snakeye Weapon is a general purpose drogue-type bomb which can be adapted to be delivered either unretarded or retarded. Unretarded, the weapons ballistics are very similar to those of the Mk 81 LDGP. When retarded (high drag mode); the trajectory drop of the weapon is about 25% greater than in the low drag mode and the impact angle is increased for improved effectiveness. The retarded feature of Snakeye Weapon provides for a lower release altitude and hence greater accuracy and release flexibility.

WING STATION LOADING CONFIGURATIONS	
WING LOADING	**EQUIPMENT-WEIGHT**
AERO 7A-1 SUSPENSION One Bomb Each Wing	2 MK 81 602 2 Aero 7A-1 104 2 Pylons 350 Total Wt 1056 One Wing Only 528
TER SUSPENSION Three Bombs Each Wing	6 MK 81 1806 2 TER 210 2 Aero 7A-1 104 2 Pylons 350 Total Wt 2470 One Wing Only 1235
MBR SUSPENSION Four Bombs Each Wing	8 MK 81 2408 2 MBR 318 2 Aero 7A-1 104 2 Pylons 350 Total Wt. 3180 One Wing Only 1590
MER SUSPENSION Four Bombs Each Wing	8 MK 81 2408 2 MER 446 2 Aero 7A-1 104 2 Pylons 350 Total Wt 3308 One Wing Only 1654

DROPPING PROCEDURE (Mechanical Fuzing)	DROPPING PROCEDURE (Electrical Fuzing)
1. Master Arm Sw – ON 2. Armament Sel Sw – Wing L or R 3. Mechanical Fuzing Sw – TAIL or NOSE 4. Stores Rel Sw - DEPRESS	1. Master Arm Sw – ON 2. Armament Sel Sw – Wing L or R 3. Option Sel Sw – AS DESIRED 4. Safe-Stby- Ready Sw – STBY (30 sec) then RDY 5. HVDC light – ON 6. Stores Rel Sw - DEPRESS

NOTE

For simultaneous releases from the Aero 7A-1 racks the Triple-Multiple Rack Fire Mode switch in each pylon must be set to the DUAL position.

To step the MER or TER stepping switch past an empty station it is necessary to have the hooks at that station open or the stores release switch must be depressed and released once for each empty station between bombs. With the -505 or -521 TER or MER, the mechanical fuzing switch must also be placed in the NOSE position to obtain automatic stepping past the empty stations.

JETTISONING PROCEDURES

See JETTISONING this section.

REFERENCES

1. Restrictions – See Figure 2-2
2. Bomb Fuzing – NAVAIR 11-5A-17 (OP 2216)
3. Preflight Inspection – NAVAIR 01-45HHH-75
4. Bomb Loading Procedures – NAVAIR 01-45HHH-75

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Figure 2–50 (U)

Mil Lead for SingleDelivery

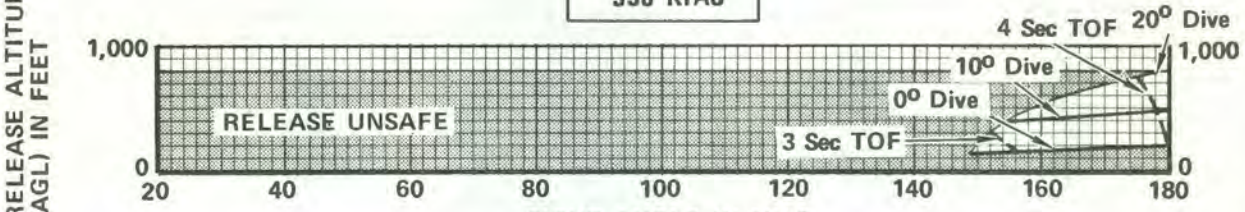
MARK 81 SNAKEYE I – RETARDED

*Mil lead corrections (±mils) for:

	350 KIAS	400 KIAS	450 KIAS	500 KIAS
Aero 7A Rack	+3	+3	+2	+2
Multiple Bomb Rack	−10	−9	−8	−8 mils
Cruise Droops Extended	+4	+4	+4	+4

RELEASE ALTITUDE TEMP VARIATION	DIVE ANGLE	0°	10°	20°
± 10° C		± 2	± 3	± 5 mils
± 30° C		± 6	± 11	± 16

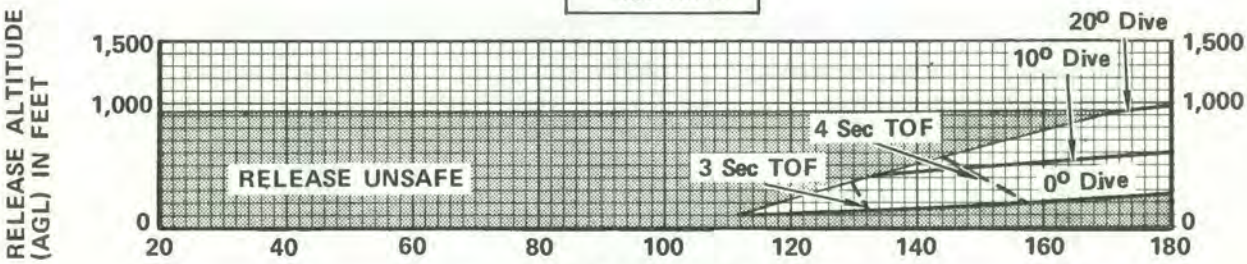
350 KIAS



RELEASE ALTITUDES FOR SPECIFIED FRAGMENT HIT PROBABILITIES

DROP ANGLE	0.000 PROBABILITY	0.001 PROBABILITY	0.010 PROBABILITY
0°	100	100*	100*
10°	420	420*	420*
20°	850	850*	850*
30°	1,510	1,510*	1,510*
40°	2,290	2,290*	2,290*
45°	2,630	2,630*	2,630*

400 KIAS



RELEASE ALTITUDES FOR SPECIFIED FRAGMENT HIT PROBABILITIES

DROP ANGLE	0.000 PROBABILITY	0.001 PROBABILITY	0.010 PROBABILITY
0°	100	100*	100*
10°	460	460*	460*
20°	970	970*	970*
30°	1,750	1,750*	1,750*
40°	2,690	2,690*	2,690*
45°	3,130	3,130*	3,130*

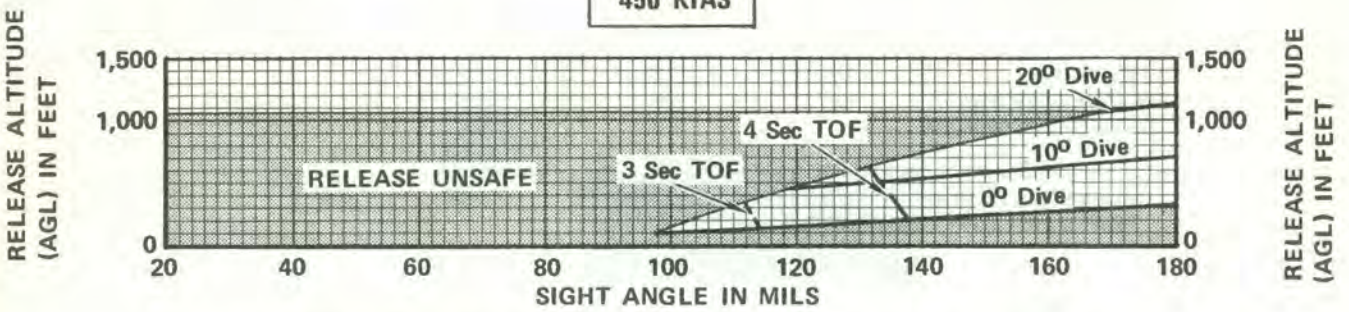
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Figure 2–51 (Sheet 1)

Mil Lead for Single Delivery

MARK 81 SNAKEYE I – RETARDED

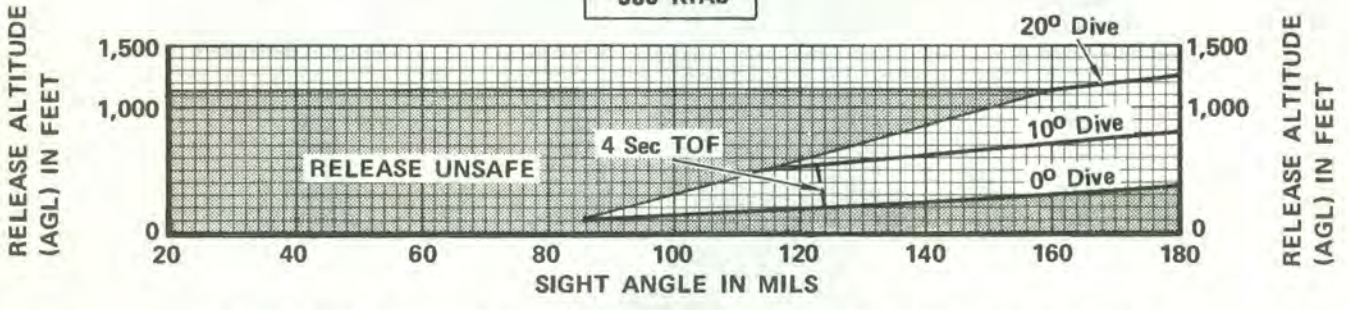
450 KIAS



RELEASE ALTITUDES FOR SPECIFIED FRAGMENT HIT PROBABILITIES

DROP ANGLE	0.000 PROBABILITY	0.001 PROBABILITY	0.010 PROBABILITY
0°	100	100*	100*
10°	500	500*	500*
20°	1,100	1,100*	1,100*
30°	2,010	2,010*	2,010*
40°	3,130	3,130*	3,130*
45°	3,680	3,680*	3,680*

500 KIAS



RELEASE ALTITUDES FOR SPECIFIED FRAGMENT HIT PROBABILITIES

DROP ANGLE	0.000 PROBABILITY	0.001 PROBABILITY	0.010 PROBABILITY
0°	100	100*	100*
10°	550	550*	550*
20°	1,240	1,240*	1,240*
30°	2,280	2,280*	2,280*
40°	3,610	3,610*	3,610*
45°	4,270	4,270*	4,270*

NOTE

Sight angles are based on 27,000 lb aircraft gross weight, 0 ft burst altitude, 0 ft target elevation, and 7.2 ft/sec average ejection velocity. Released from MER or TER.

For increase (decrease) in temperature, increase (decrease) the mil lead; linear interpolation shall be used for nonstandard temperatures other than those given.

*Terrain avoidance is determining factor for this release altitude limitation.

AZ-224(2)-01-69

Figure 2-51 (Sheet 2)

MARK 81 SNAKEYE I – RETARDED

DIVE ANGLE	MIL LEAD		ENTRY			RELEASE			CORRECTION PER 10 KT OF DIRECT WIND – MILS		RELEASE ERROR SENSITIVITIES		
	EJECTED MILS	NON-EJECTED (MBR) – MILS	KIAS	ALTITUDE FT AGL	APPROX RPM %	KTAS	ALTITUDE FT AGL	ALTIMETER LAG – FT	Range	Cross	FT/KT KIAS	FT/100 FT ALTITUDE	FT/DEG DIVE ANGLE
LEVEL	144	137	435	150	93	450	150	0	3	35	2.5	750	Climb -300 Dive +170
10°	138	135	400	3,000	91	450	500	125	3	35	2	160	50

NOTES

1. Error sensitivities are applied as follows:

   Airspeed – Fast impacts long
   Slow impacts short

   Altitude – High impacts short
   Low impacts long

   Dive Angle – Steep impacts long
   Shallow impacts short

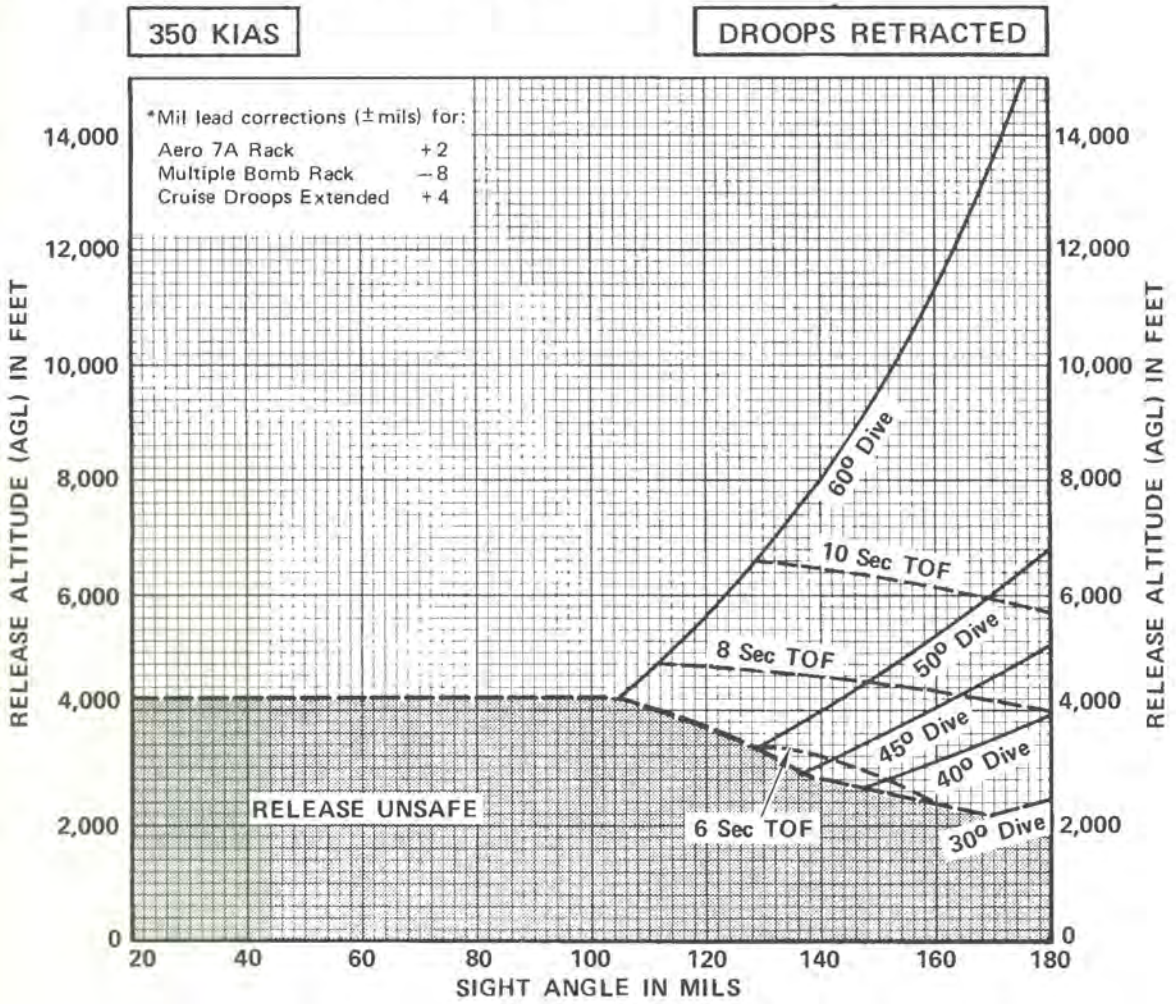
2. F-8 used in test was flown with cruise droop extended.

AZ-238-2-67

Figure 2–52

Mil Lead for Single Delivery

MARK 81 SNAKEYE I – UNRETARDED



RELEASE ALTITUDES FOR SPECIFIED FRAGMENT HIT PROBABILITIES

DROP ANGLE	0.000 PROBABILITY	0.001 PROBABILITY	0.010 PROBABILITY
0°	1,360	1,070	760
10°	1,190	1,040	800
20°	1,620	1,490	1,210
30°	2,040	1,940	1,620
40°	2,550	2,390	2,290
45°	2,750	2,630	2,630†
50°	3,310	3,310†	3,310†
60°	4,150	4,150†	4,150†

NOTE

Sight angles are based on 27,000 lb aircraft gross weight, 0 ft burst altitude, 0 ft target elevation, and 7.2 ft/sec average ejection velocity. Released from MER or TER.

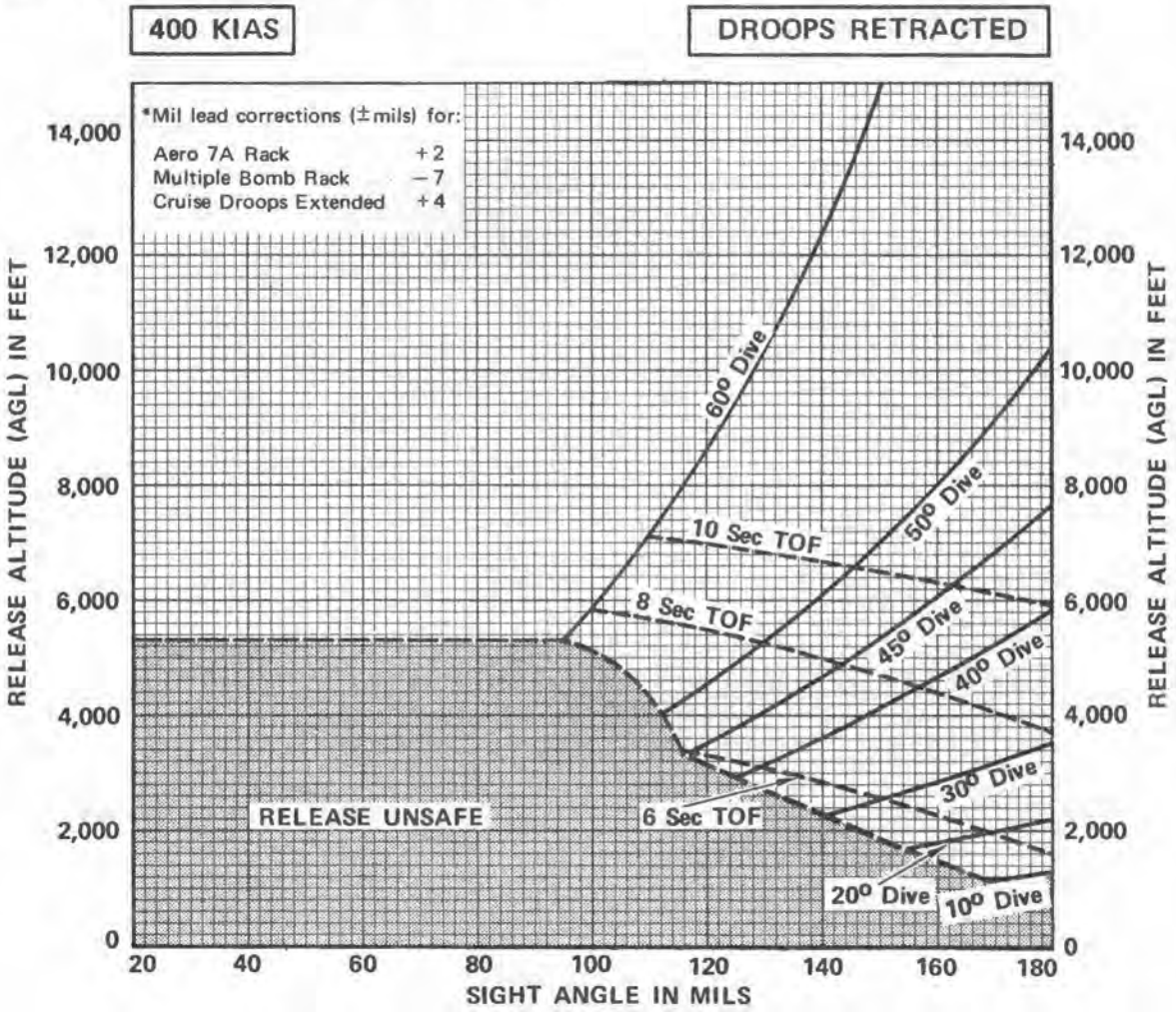
*For each 10° C increase (decrease) in release altitude temperature, increase (decrease) the mil lead by 3 mils.
†Terrain avoidance is determining factor for this release altitude limitation.

AZ-214(1)-02-69

Figure 2–53 (Sheet 1)

Mil Lead for SingleDelivery

MARK 81 SNAKEYE I – UNRETARDED



RELEASE ALTITUDES FOR SPECIFIED FRAGMENT HIT PROBABILITIES

DROP ANGLE	0.000 PROBABILITY	0.001 PROBABILITY	0.010 PROBABILITY
0°	1,080	910	670
10°	1,110	1,020	810
20°	1,720	1,540	1,300
30°	2,220	2,070	1,750
40°	2,760	2,690	2,690†
45°	3,130	3,130†	3,130†
50°	3,930	3,930†	3,930†
60°	5,040	5,040†	5,040†

NOTE

Sight angles are based on 27,000 lb aircraft gross weight, 0 ft burst altitude, 0 ft target elevation, and 7.2 ft/sec average ejection velocity. Released from MER or TER.

*For each 10° C increase (decrease) in release altitude temperature, increase (decrease) the mil lead by 3 mils.

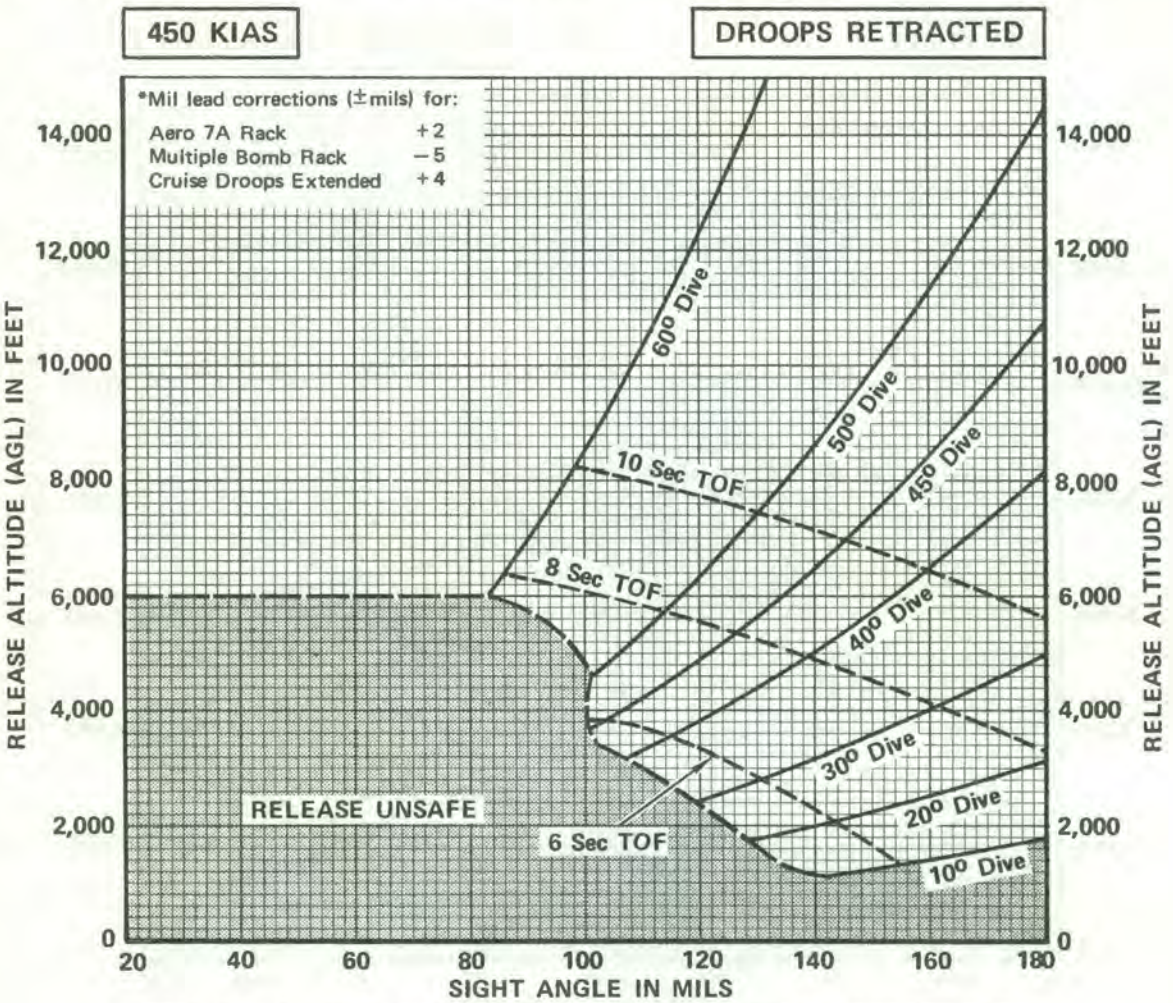
†Terrain avoidance is determining factor for this release altitude limitation.

AZ-214(2)-02-69

Figure 2–53 (Sheet 2)

Mil Lead for Single Delivery

MARK 81 SNAKEYE I – UNRETARDED



RELEASE ALTITUDES FOR SPECIFIED FRAGMENT HIT PROBABILITIES

DROP ANGLE	0.000 PROBABILITY	0.001 PROBABILITY	0.010 PROBABILITY
0°	890	810	610
10°	1,190	1,010	840
20°	1,800	1,580	1,390
30°	2,330	2,110	2,010
40°	3,130	3,130†	3,130†
45°	3,680	3,680†	3,680†
50°	4,610	4,610†	4,610†
60°	6,030	6,030†	6,030†

NOTE

Sight angles are based on 27,000 lb aircraft gross weight, 0 ft burst altitude, 0 ft target elevation, and 7.2 ft/sec average ejection velocity. Released from MER or TER.

*For each 10° C increase (decrease) in release altitude temperature, increase (decrease) the mil lead by 3 mils.

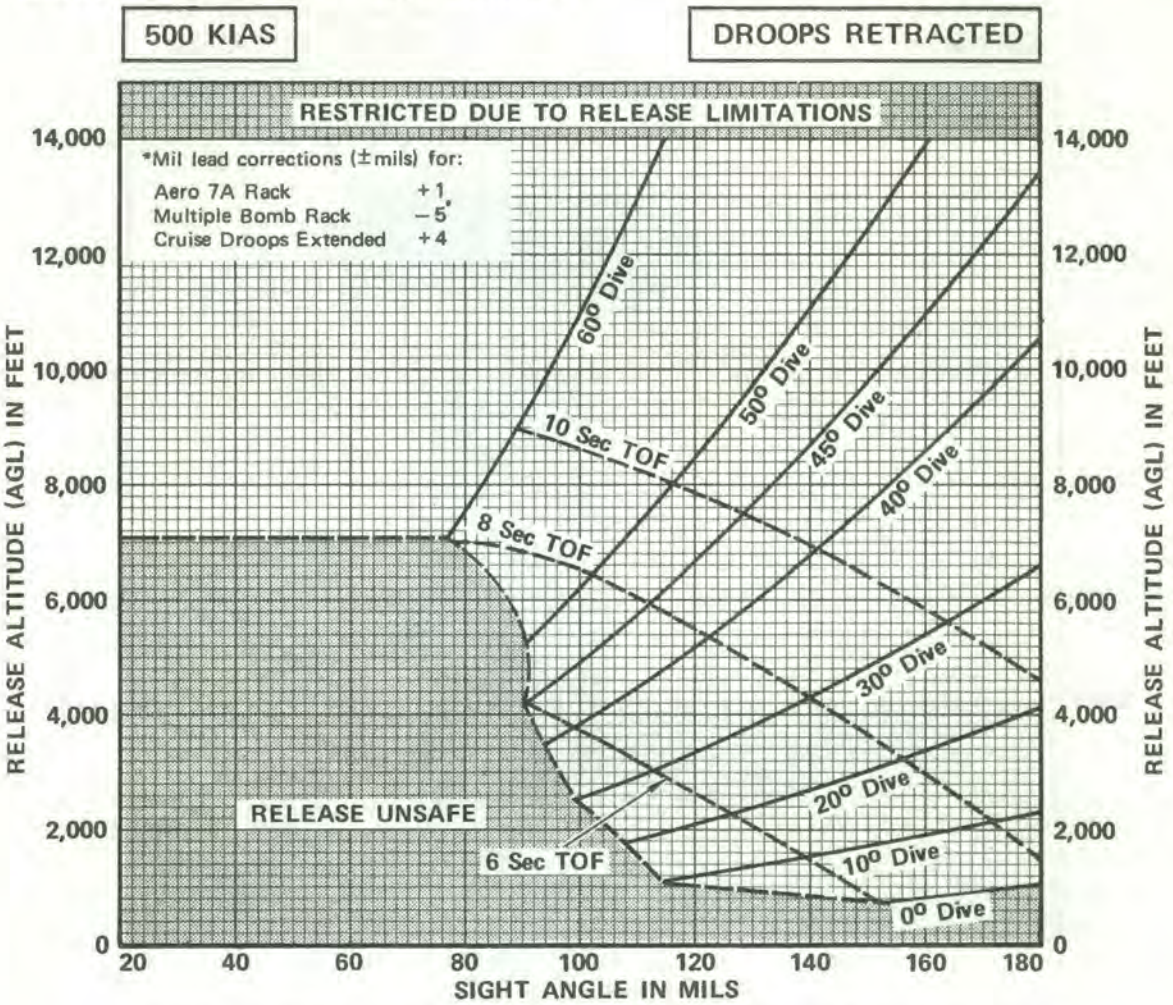
†Terrain avoidance is determining factor for this release altitude limitation.

AZ-214(3)-02-69

Figure 2-53 (Sheet 3)

Mil Lead for Single Delivery

MARK 81 SNAKEYE I – UNRETARDED



RELEASE ALTITUDES FOR SPECIFIED FRAGMENT HIT PROBABILITIES

DROP ANGLE	0.000 PROBABILITY	0.001 PROBABILITY	0.010 PROBABILITY
0°	780	670	560
10°	1,100	1,000	880
20°	1,800	1,610	1,460
30°	2,430	2,280†	2,280†
40°	3,610	3,610†	3,610†
45°	4,270	4,270†	4,270†
50°	5,340	5,340†	5,340†
60°	7,040	7,040†	7,040†

NOTE

Sight angles are based on 27,000 lb aircraft gross weight, 0 ft burst altitude, 0 ft target elevation, and 7.2 ft/sec average ejection velocity. Released from MER or TER.

*For each 10° C increase (decrease) in release altitude temperature, increase (decrease) the mil lead by 3 mils.

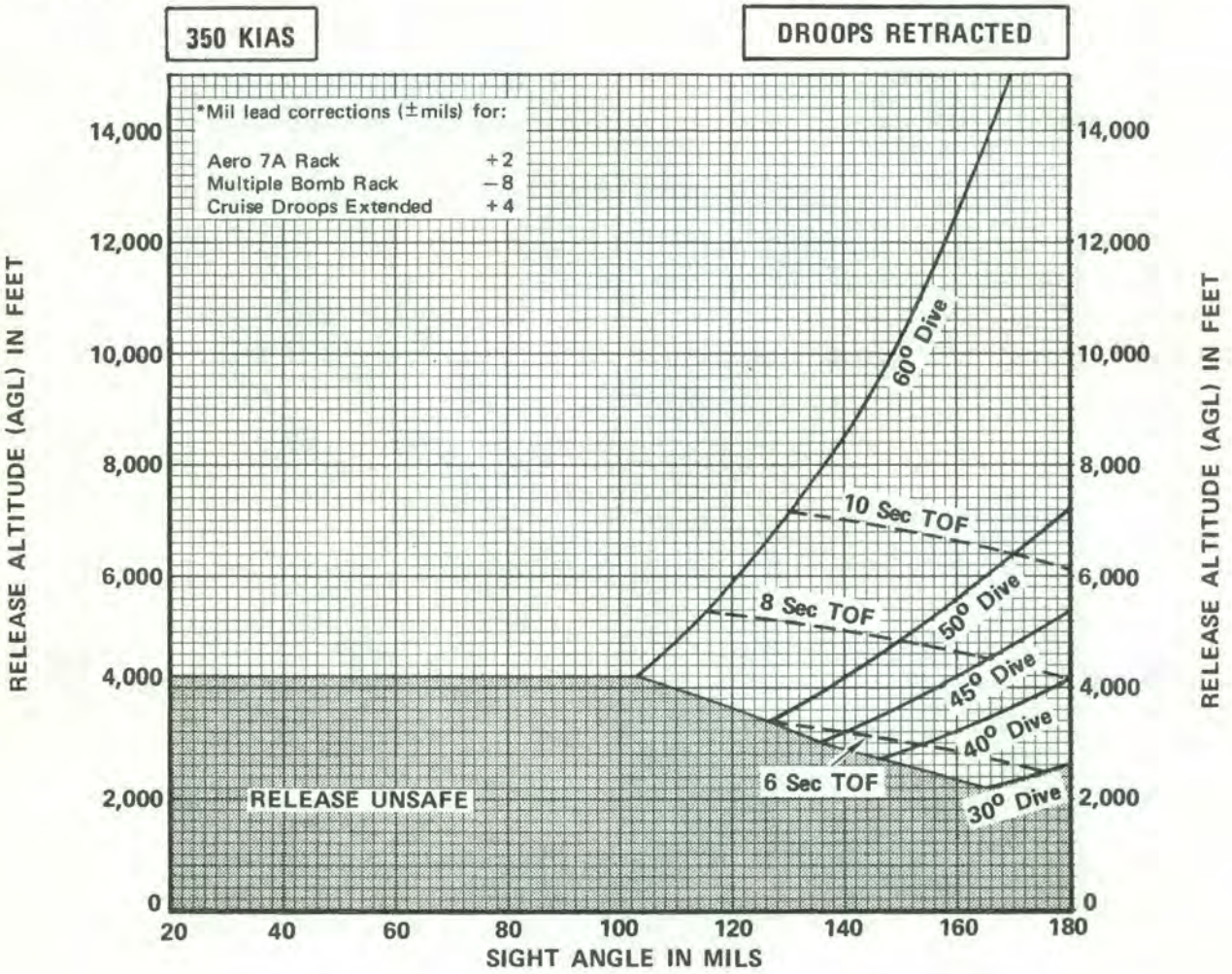
†Terrain avoidance is determining factor for this release altitude limitation.

AZ-214(4)-02-69

Figure 2–53 (Sheet 4)

Mil Lead for Single Delivery

MARK 81 CONICAL FIN



RELEASE ALTITUDES FOR SPECIFIED FRAGMENT HIT PROBABILITIES

DROP ANGLE	0.000 PROBABILITY	0.001 PROBABILITY	0.010 PROBABILITY
0°	1,470	1,200	810
10°	1,200	1,070	860
20°	1,700	1,530	1,270
30°	2,120	1,990	1,700
40°	2,550	2,440	2,290
45°	2,780	2,650	2,630
50°	3,310	3,310†	3,310†
60°	4,150	4,150†	4,150†

NOTE

Sight angles are based on 27,000 lb aircraft gross weight, 0 ft burst altitude, 0 ft target elevation, and 7.2 ft/sec average ejection velocity. Released from MER or TER.

*For each 10° C increase (decrease) in release altitude temperature, increase (decrease) the mil lead by 3 mils.

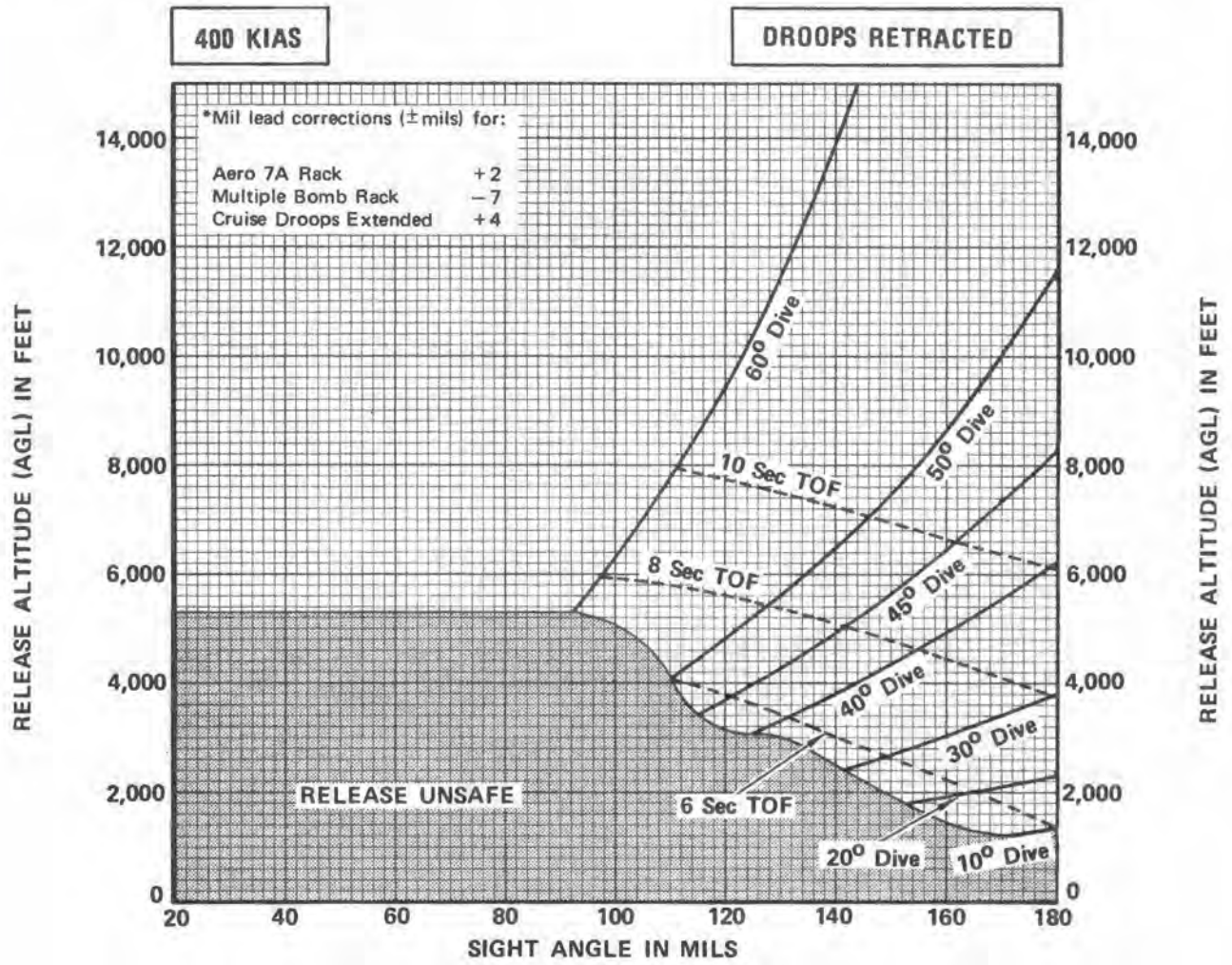
†Terrain avoidance is determining factor for this release altitude limitation.

AZ-215(1)-02-69

Figure 2-54 (Sheet 1)

Mil Lead for Single Delivery

MARK 81 CONICAL FIN



RELEASE ALTITUDES FOR SPECIFIED FRAGMENT HIT PROBABILITIES

DROP ANGLE	0.000 PROBABILITY	0.001 PROBABILITY	0.010 PROBABILITY
0°	1,290	1,080	760
10°	1,200	1,060	870
20°	1,720	1,600	1,310
30°	2,250	2,150	1,820
40°	2,790	2,690	2,690†
45°	3,130	3,130†	3,130†
50°	3,930	3,930†	3,930†
60°	5,040	5,040†	5,040†

NOTE

Sight angles are based on 27,000 lb aircraft gross weight, 0 ft burst altitude, 0 ft target elevation, and 7.2 ft/sec average ejection velocity. Released from MER or TER.

*For each 10° C increase (decrease) in release altitude temperature, increase (decrease) the mil lead by 3 mils.

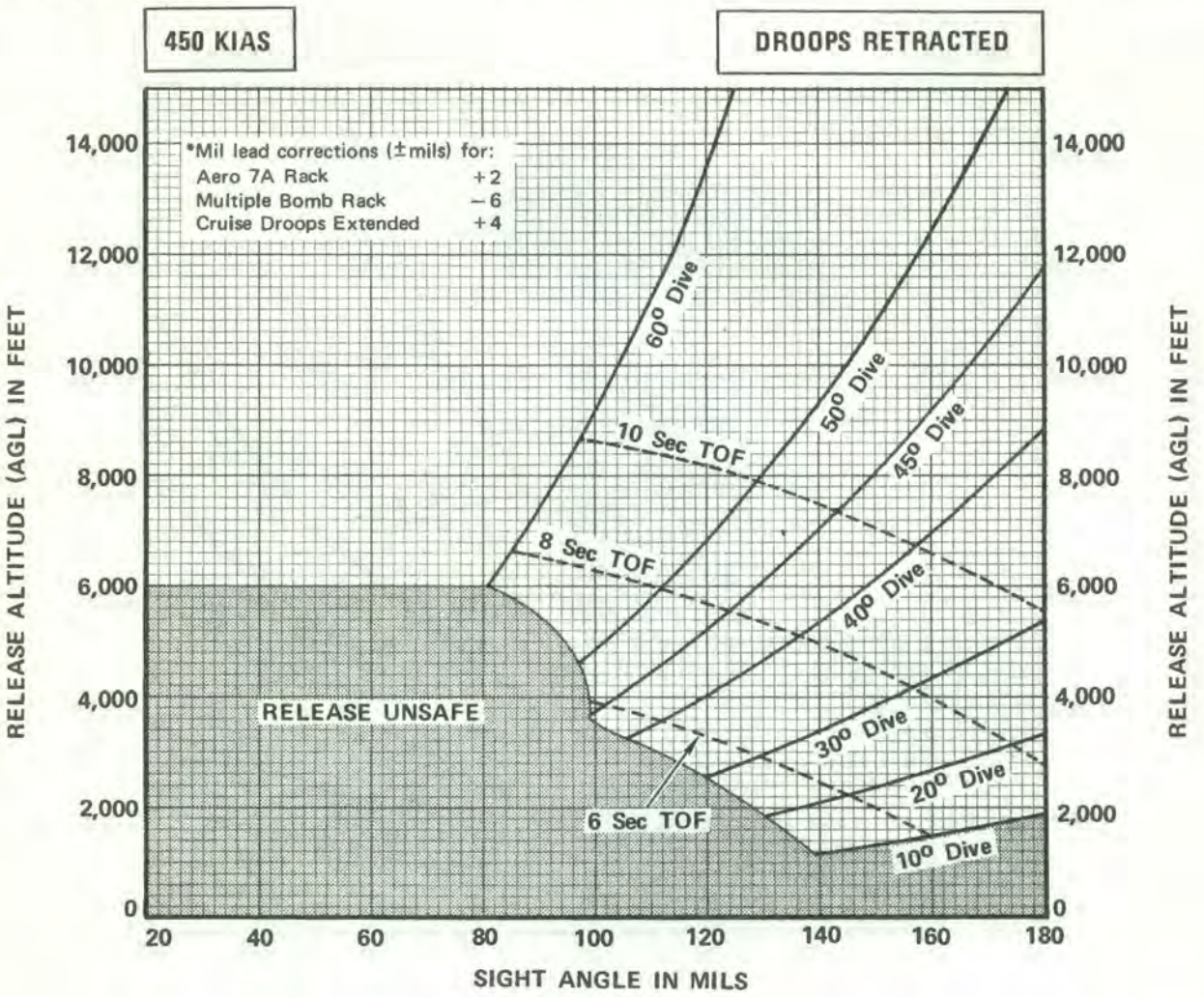
†Terrain avoidance is determining factor for this release altitude limitation.

AZ-215(2)-03-69

Figure 2-54 (Sheet 2)

Mil Lead for Single Delivery

MARK 81 CONICAL FIN



RELEASE ALTITUDES FOR SPECIFIED FRAGMENT HIT PROBABILITIES

DROP ANGLE	0.000 PROBABILITY	0.001 PROBABILITY	0.010 PROBABILITY
0°	1,170	960	680
10°	1,200	1,050	890
20°	1,820	1,690	1,420
30°	2,430	2,310	2,010
40°	3,130	3,130†	3,130†
45°	3,680	3,680†	3,680†
50°	4,610	4,610†	4,610†
60°	6,030	6,030†	6,030†

NOTE

Sight angles are based on 27,000 lb aircraft gross weight, 0 ft burst altitude, 0 ft target elevation, and 7.2 ft/sec average ejection velocity. Released from MER or TER.

*For each 10° C increase (decrease) in release altitude temperature, increase (decrease) the mil lead by 3 mils.

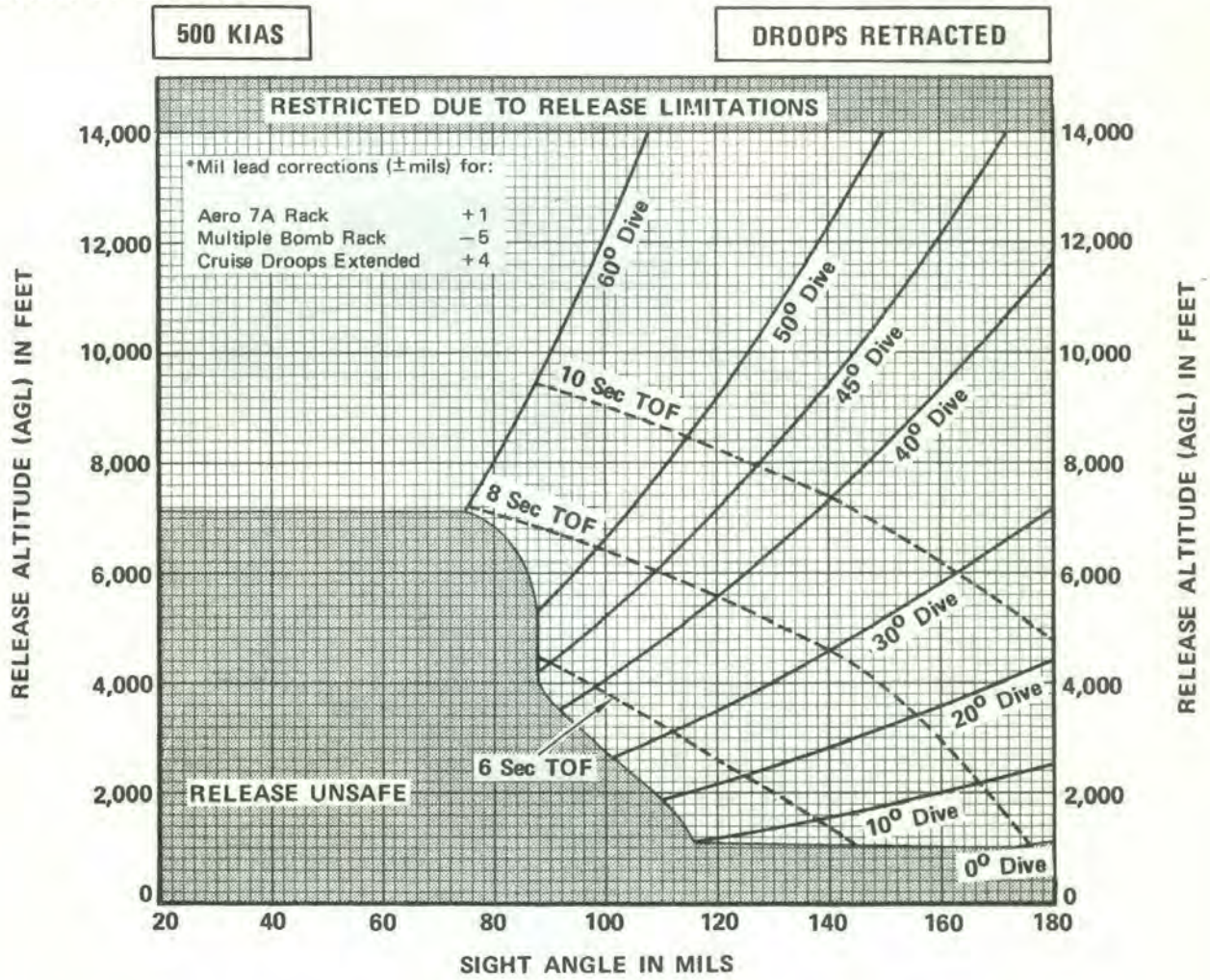
†Terrain avoidance is determining factor for this release altitude limitation.

AZ-215(3)-02-69

Figure 2-54 (Sheet 3)

Mil Lead for Single Delivery

MARK 81 CONICAL FIN



RELEASE ALTITUDES FOR SPECIFIED FRAGMENT HIT PROBABILITIES

DROP ANGLE	0.000 PROBABILITY	0.001 PROBABILITY	0.010 PROBABILITY
0°	990	830	680
10°	1,200	1,070	910
20°	1,900	1,770	1,520
30°	2,530	2,440	2,280
40°	3,610	3,610†	3,610†
45°	4,270	4,270†	4,270†
50°	5,340	5,340†	5,340†
60°	7,040	7,040†	7,040†

NOTE

Sight angles are based on 27,000 lb aircraft gross weight, 0 ft burst altitude, 0 ft target elevation, and 7.2 ft/sec average ejection velocity. Released from MER or TER.

*For each 10° C increase (decrease) in release altitude temperature, increase (decrease) the mil lead by 3 mils.

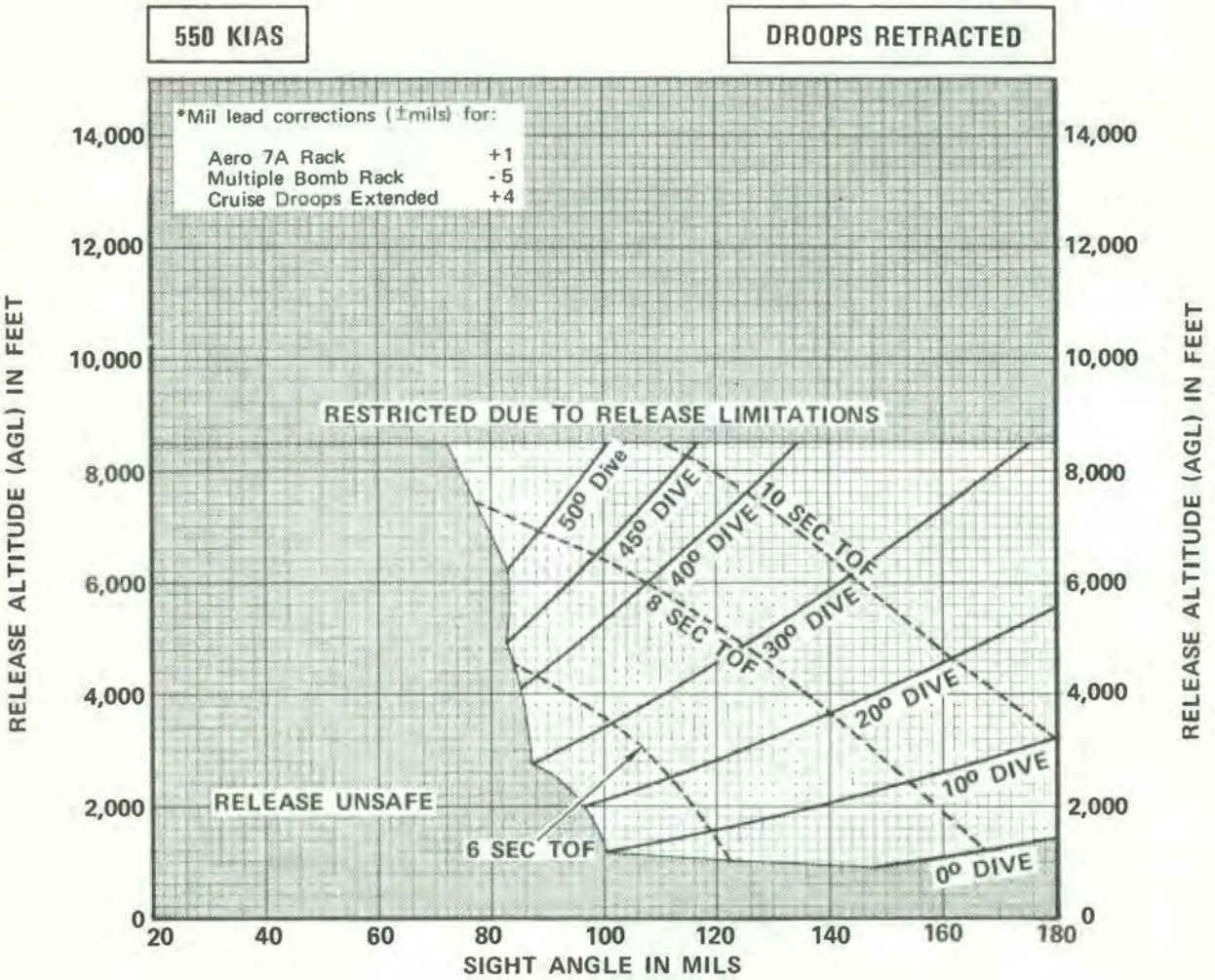
†Terrain avoidance is determining factor for this release altitude limitation.

AZ-215(4)-02-69

Figure 2–54 (Sheet 4)

Mil Lead for Single Delivery

MARK 81 CONICAL FIN



RELEASE ALTITUDES FOR SPECIFIED FRAGMENT HIT PROBABILITIES

DROP ANGLE	0.000 PROBABILITY	0.001 PROBABILITY	0.010 PROBABILITY
0°	880	780	600
10°	1,200	1,100	950
20°	1,910	1,830	1,600
30°	2,640	2,570	2,570†
40°	4,080	4,080†	4,080†
45°	4,840	4,840†	4,840†
50°	6,000	6,000†	6,000†
60°	7,920	7,920†	7,920†

NOTE

Sight angles are based on 27,000 lb aircraft gross weight, 0 ft burst altitude, 0 ft target elevation, and 7.2 ft/sec average ejection velocity. Released from MER or TER.

*For each 10°C increase (decrease) in release altitude temperature increase (decrease) the mil lead by 3 mils.

†Terrain avoidance is determining factor for this release altitude limitation.

AZ-215(5)-02-69

Figure 2-54 (Sheet 5)

Maximum Fragment Envelope

MK 81 GENERAL PURPOSE AND SNAKEYE I (RETARDED OR UNRETARDED)

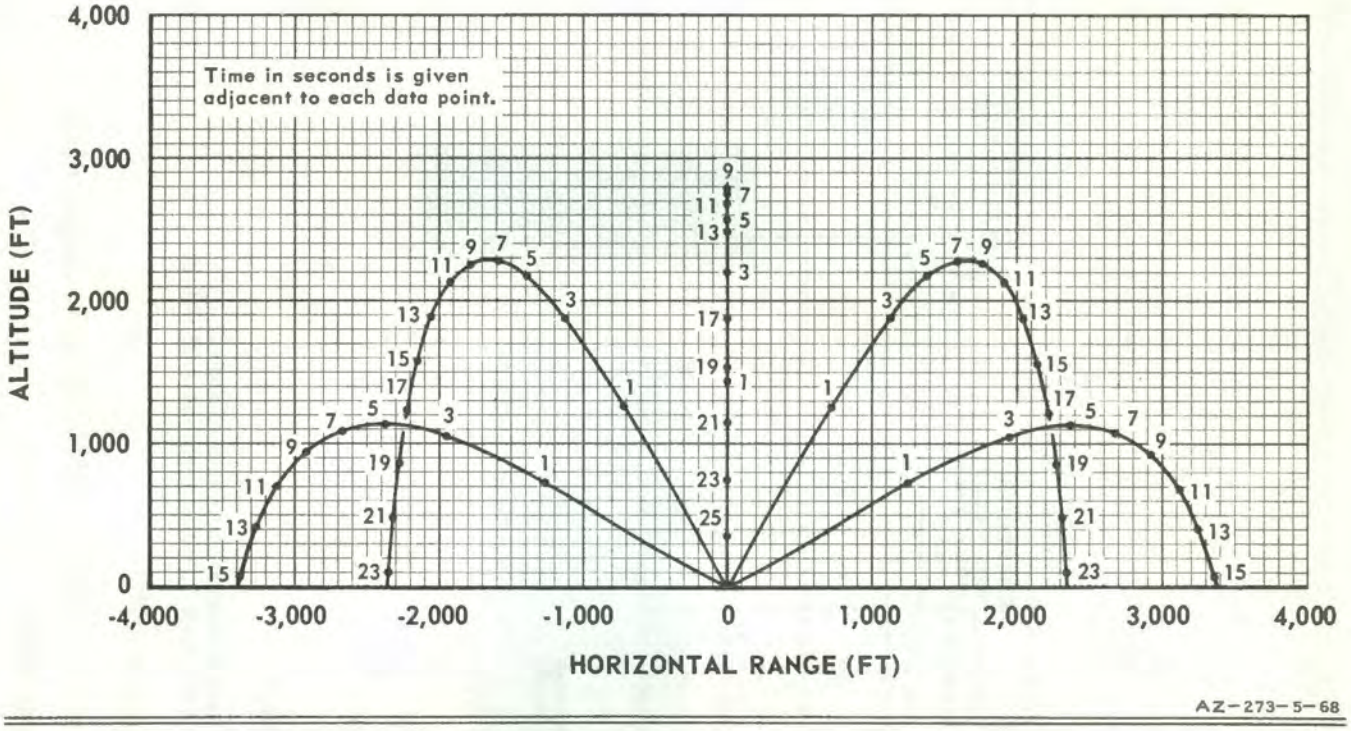


Figure 2–55

MARK 81 CONICAL FIN

DIVE ANGLE	MIL LEAD		ENTRY			RELEASE			CORRECTION PER 10 KT OF DIRECT WIND – MILS		RELEASE ERROR SENSITIVITIES				
	EJECTED MILS	NON-EJECTED (MBR) – MILS	KIAS	ALTITUDE FT AGL	APPROX RPM %	KTAS	ALTITUDE FT AGL	ALTIMETER LAG – FT	Range	Cross	FT/KT KIAS	FT/100 FT ALTITUDE	FT/DEG DIVE ANGLE	FT/MIL RANGE	FT/MIL DEFLECTION
30°	114	108	350	7,000	94	500	2,500	250	11	19	2	20	22	8	5
45°	115	108	250	10,000	86	450	3,500	0	16	20	2	10	15	6	5
45°	125	118	250	10,500	86	450	4,000	0	16	20	2	10	15	6	5

NOTES

1. Error sensitivities are applied as follows:

   Airspeed – Fast impacts long
   Slow impacts short

   Altitude – High impacts short
   Low impacts long

   Dive Angle – Steep impacts long
   Shallow impacts short

2. Mil lead computed for 28,000 lb aircraft with cruise droop extended.
   Correction – Add/subtract 1 mil for each 1,000 lb over/under 28,000 lb.

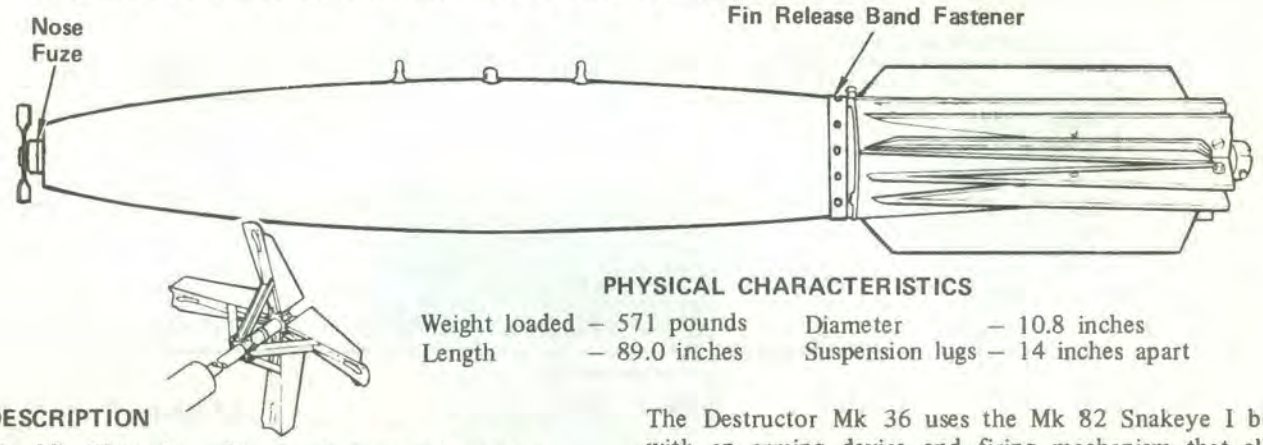
3. 45° dive profiles flown with speed brakes OUT.

AZ-242-2-67

Figure 2–56

MK 82 GP Bomb Snakeye I

DESTRUCTOR MK 36 AND MK 124 PRACTICE BOMB



PHYSICAL CHARACTERISTICS

Weight loaded – 571 pounds
Length – 89.0 inches
Diameter – 10.8 inches
Suspension lugs – 14 inches apart

DESCRIPTION

The Mk 82 Snakeye Weapon is a general purpose drogue-type bomb which can be adapted for delivery either retarded or unretarded. Unretarded the weapon follows a free-fall trajectory. Retarded, the trajectory drop of the weapon is about 25% greater than in the low-drag mode and the impact angle increases for improved effectiveness. The retarded mode allows lower release altitude and gives greater accuracy and release flexibility.

The Destructor Mk 36 uses the Mk 82 Snakeye I bomb with an arming device and firing mechanism that allows the weapon to function as an influence weapon against shallow water and land targets. The Mk 124 is a full scale, retarded or free-fall practice bomb for fleet training in Snakeye I and conical versions of the Mk 82 series. The Mk 82 mil lead charts are applicable to the Mk 36 and the Mk 124.

WING STATION LOADING CONFIGURATIONS

WING LOADING	EQUIPMENT-WEIGHT
AERO 7A SUSPENSION One Bomb Each Wing	2 MK 82 1142 2 Aero 7A-1 104 2 Pylons 350 Total 1596 One Wing Only 798
TER SUSPENSION Three Bombs Each Wing	6 MK 82 3426 2 TER 210 2 Aero 7A-1 104 2 Pylons 350 Total 4090 One Wing Only 2045
MER SUSPENSION Three Bombs Each Wing	6 MK 82 3426 2 MER 446 2 Aero 7A-1 104 2 Pylons 350 Total 4326 One Wing Only 2163
MBR SUSPENSION Three Bombs Each Wing	6 MK 82 3426 2 MBR 318 2 Aero 7A-1 104 2 Pylons 350 Total 4198 One Wing Only 2099

DROPPING PROCEDURE
(Mechanical Fuzing)

1. Master Arm Sw – ON
2. Armament Sel Sw – Wing L or R
3. Mechanical Fuzing Sw – NOSE or TAIL
4. Stores Release Sw – DEPRESS

DROPPING PROCEDURE
(Electrical Fuzing)

1. Master Arm Sw – ON
2. Armament Sel Sw – Wing L or R
3. Option Sel Sw – As Desired
4. Safe-Stby-Ready Sw – STDY (30 sec) then RDY
5. HV DC Light – ON
6. Stores Release Sw – DEPRESS

NOTE

For simultaneous releases from the Aero 7A-1 racks, the Triple-Multiple Rack Fire Mode switch in each pylon must be set to the DUAL position and the Arm Sel Sw in the WING, L position.

To step the MER or TER stepping switch past an empty station, it is necessary to have the hooks at that station open or the stores release switch must be depressed and released once for each empty station between bombs. With the -505 or -521 TER or MER, the mechanical fuzing switch must also be placed in the NOSE position to obtain automatic stepping past empty stations.

JETTISONING PROCEDURES

See JETTISONING, this section.

REFERENCES

1. Restrictions – See Figure 2-2
2. Bomb Fuzing – NAVAIR 11-5A-17 (OP 2216) and DST 36 OP 3529 (Mk 36)
3. Preflight Inspection – NAVAIR 01-45HH-75
4. Bomb Loading Procedures – NAVAIR 01-45HH-75

AZ-93-03-70

Figure 2-57 (U)

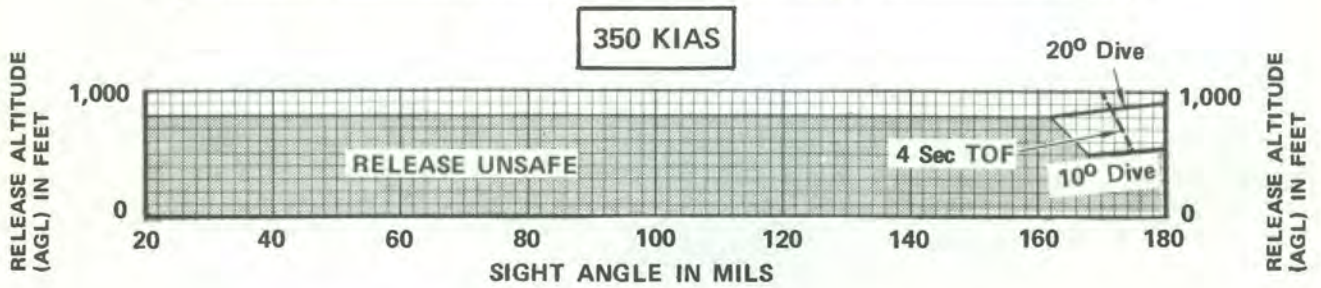
Mil Lead for Single Delivery

MARK 82 SNAKEYE 1 – RETARDED

*Mil lead corrections (±mils) for:

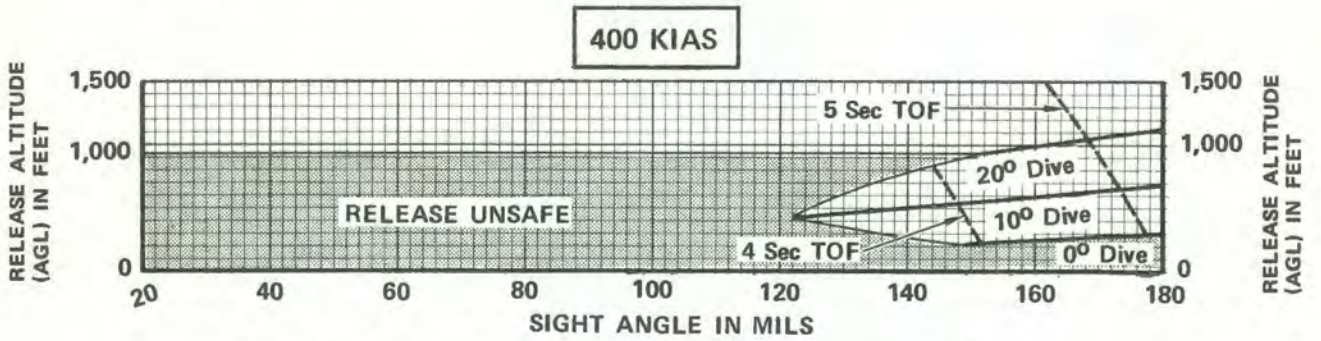
	350 KIAS	400 KIAS	450 KIAS	500 KIAS
Aero 7A Rack	+1	+1	+1	+1
Multiple Bomb Rack	−7	−7	−6	−6 mils
Cruise Droops Extended	+4	+4	+4	+4

RELEASE ALTITUDE TEMP VARIATION	DIVE ANGLE 0°	10°	20°	
± 10° C	± 2	± 3	± 5	
± 30° C	± 8	± 11	± 14	mils



RELEASE ALTITUDES FOR SPECIFIED FRAGMENT HIT PROBABILITIES

DROP ANGLE	0.000 PROBABILITY	0.001 PROBABILITY	0.010 PROBABILITY
0°	200	200*	100
10°	500	420*	420*
20°	850	850*	850*
30°	1,510	1,510*	1,510*
40°	2,290	2,290*	2,290*
45°	2,630	2,630*	2,630*



RELEASE ALTITUDES FOR SPECIFIED FRAGMENT HIT PROBABILITIES

DROP ANGLE	0.000 PROBABILITY	0.001 PROBABILITY	0.010 PROBABILITY
0°	200	100*	100*
10°	460	460*	460*
20°	970	970*	970*
30°	1,750	1,750*	1,750*
40°	2,690	2,690*	2,690*
45°	3,130	3,130*	3,130*

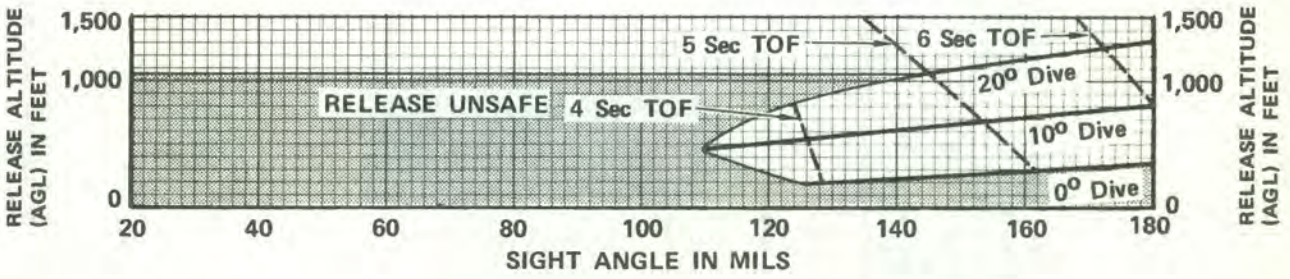
AZ-225(1)-02-69

Figure 2–58 (Sheet 1)

Mil Lead for Single Delivery

MARK 82 SNAKEYE I – RETARDED

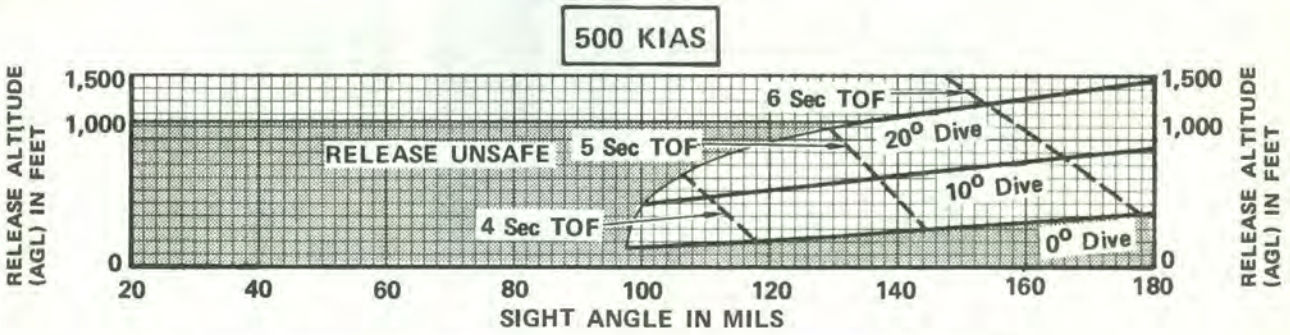
450 KIAS



RELEASE ALTITUDES FOR SPECIFIED FRAGMENT HIT PROBABILITIES

DROP ANGLE	0.000 PROBABILITY	0.001 PROBABILITY	0.010 PROBABILITY
0°	100	100*	100*
10°	500	500*	500*
20°	1,100	1,100*	1,100*
30°	2,010	2,101*	2,010*
40°	3,130	3,130*	3,130*
45°	3,680	3,680*	3,680*

500 KIAS



RELEASE ALTITUDES FOR SPECIFIED FRAGMENT HIT PROBABILITIES

DROP ANGLE	0.000 PROBABILITY	0.001 PROBABILITY	0.010 PROBABILITY
0°	100	100*	100*
10°	550	550*	550*
20°	1,240	1,240*	1,240*
30°	2,280	2,280*	2,280*
40°	3,610	3,610*	3,610*
45°	4,270	4,270*	4,270*

NOTE

Sight angles are based on 27,000 lb aircraft gross weight, 0 ft burst altitude, 0 ft target elevation, and 5.6 ft/sec average ejection velocity. Released from MER or TER.

For increase (decrease) in temperature, increase (decrease) the mil lead; linear interpolation shall be used for nonstandard temperatures other than those given.

* Terrain avoidance is determining factor for this release altitude limitation.

AZ-225(2)-02-69

Figure 2-58 (Sheet 2)

MARK 82 SNAKEYE I – RETARDED

DIVE ANGLE	MIL LEAD		ENTRY			RELEASE			CORRECTION PER 10 KT OF DIRECT WIND – MILS		RELEASE ERROR SENSITIVITIES		
	EJECTED MILS	NON-EJECTED (MBR) – MILS	KIAS	ALTITUDE FT AGL	APPROX RPM %	KTAS	ALTITUDE FT AGL	ALTIMETER LAG – FT	Range	Cross	FT/KT KIAS	FT/100 FT ALTITUDE	FT/DEG DIVE ANGLE
LEVEL	135	128	435	150	94	450	150	0	3	35	2.5	750	Climb -300 Dive +170
10°	130	128	400	3,000	90	450	500	125	3	35	2	160	50

NOTES

1. Error sensitivities are applied as follows:

   Airspeed – Fast impacts long
   Slow impacts short

   Altitude – High impacts short
   Low impacts long

   Dive Angle – Steep impacts long
   Shallow impacts short

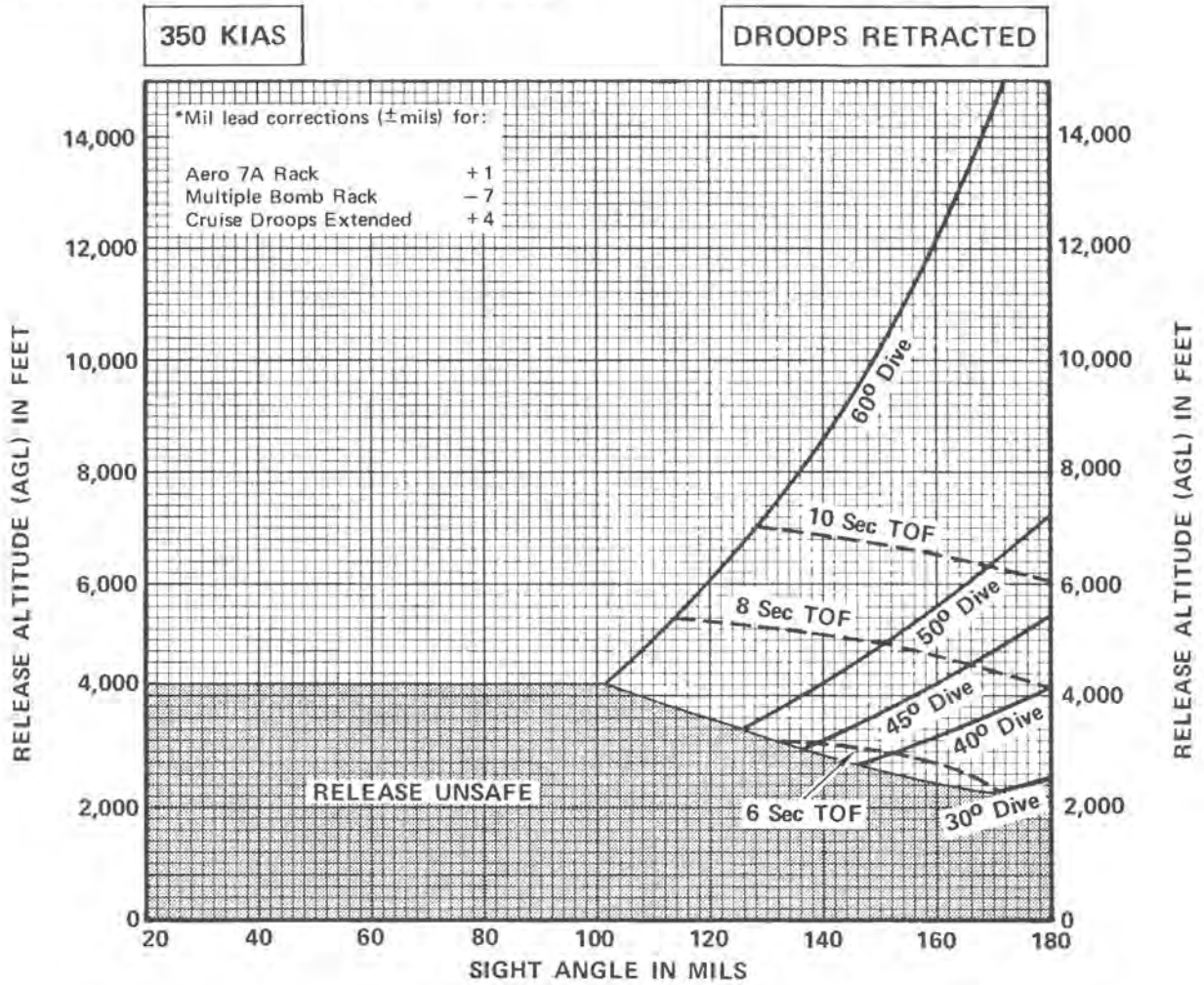
2. F-8 used in test was flown with cruise droop extended.

AZ-239-2-67

Figure 2–59

Mil Lead for Single Delivery

MARK 82 SNAKEYE I – UNRETARDED



RELEASE ALTITUDES FOR SPECIFIED FRAGMENT HIT PROBABILITIES

DROP ANGLE	0.000 PROBABILITY	0.001 PROBABILITY	0.010 PROBABILITY
0°	1,370	1,100	970
10°	1,200	950	900
20°	1,700	1,400	1,340
30°	2,120	1,830	1,760
40°	2,550	2,290	2,290†
45°	2,780	2,630	2,630†
50°	3,310	3,310†	3,310†
60°	4,150	4,150†	4,150†

NOTE

Sight angles are based on 27,000 lb aircraft gross weight, 0 ft burst altitude, 0 ft target elevation, and 5.6 ft/sec average ejection velocity. Released from MER or TER.

*For each 10° C increase (decrease) in release altitude temperature, increase (decrease) the mil lead by 3 mils.

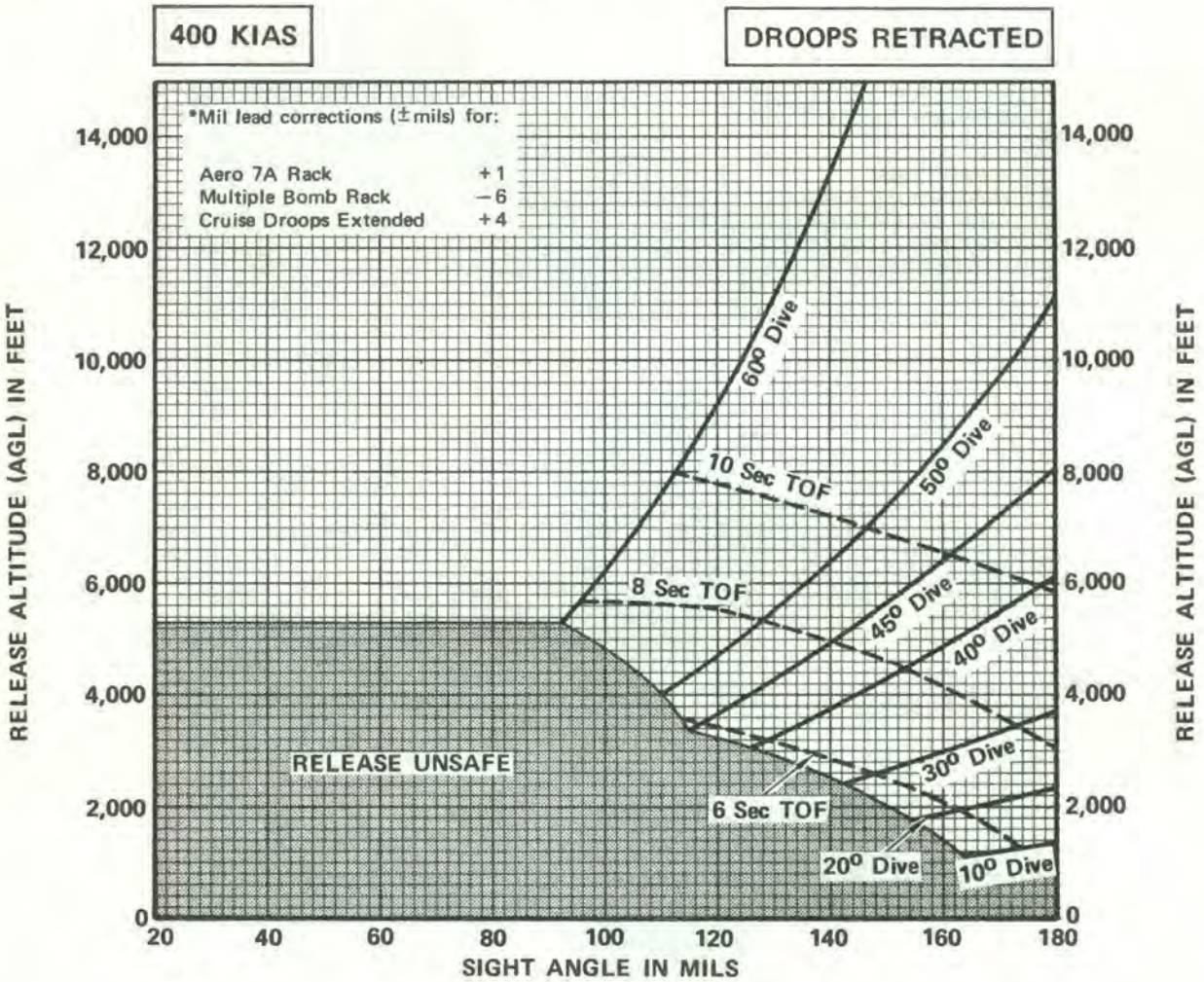
†Terrain avoidance is determining factor for this release altitude limitation.

AZ-216(1)-02-69

Figure 2-60 (Sheet 1)

Mil Lead for Single Delivery

MARK 82 SNAKEYE I – UNRETARDED



RELEASE ALTITUDES FOR SPECIFIED FRAGMENT HIT PROBABILITIES

DROP ANGLE	0.000 PROBABILITY	0.001 PROBABILITY	0.010 PROBABILITY
0°	1,180	960	840
10°	1,200	980	900
20°	1,720	1,460	1,390
30°	2,250	1,980	1,890
40°	2,790	2,690	2,690†
45°	3,130	3,130†	3,130†
50°	3,930	3,930†	3,930†
60°	5,040	5,040†	5,040†

NOTE

Sight angles are based on 27,000 lb aircraft gross weight, 0 ft burst altitude, 0 ft target elevation, and 5.6 ft/sec average ejection velocity. Released from MER or TER.

*For each 10° C increase (decrease) in release altitude temperature, increase (decrease) the mil lead by 3 mils.

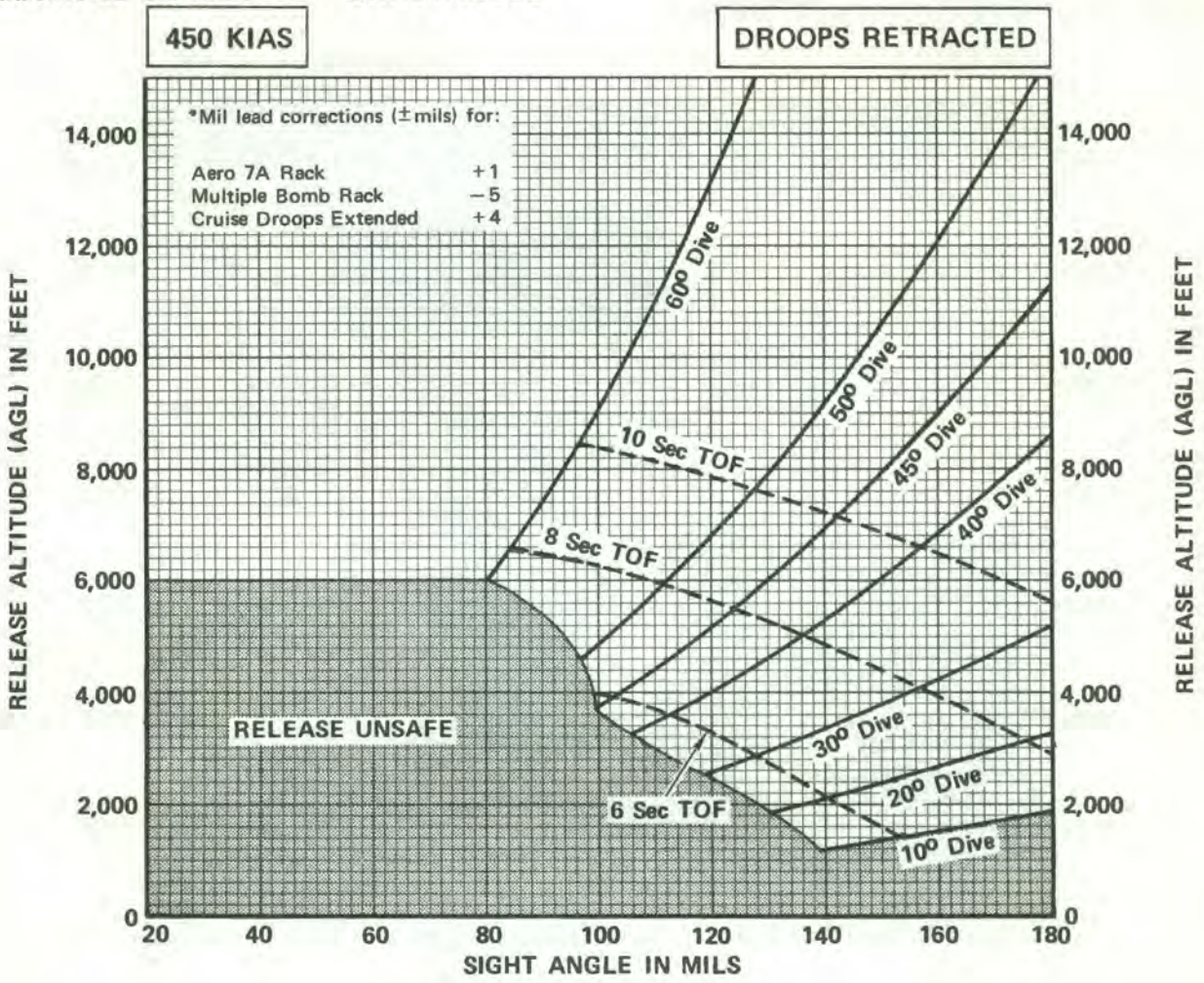
†Terrain avoidance is determining factor for this release altitude limitation.

AZ-216(2)-02-89

Figure 2–60 (Sheet 2)

Mil Lead for Single Delivery

MARK 82 SNAKEYE I – UNRETARDED



RELEASE ALTITUDES FOR SPECIFIED FRAGMENT HIT PROBABILITIES

DROP ANGLE	0.000 PROBABILITY	0.001 PROBABILITY	0.010 PROBABILITY
0°	980	820	750
10°	1,200	990	940
20°	1,820	1,550	1,480
30°	2,430	2,120	2,030
40°	3,130	3,130†	3,130†
45°	3,680	3,680†	3,680†
50°	4,610	4,610†	4,610†
60°	6,030	6,030†	6,030†

NOTE

Sight angles are based on 27,000 lb aircraft gross weight, 0 ft burst altitude, 0 ft target elevation, and 5.6 ft/sec average ejection velocity. Released from MER or TER.

*For each 10° C increase (decrease) in release altitude temperature, increase (decrease) the mil lead by 3 mils.

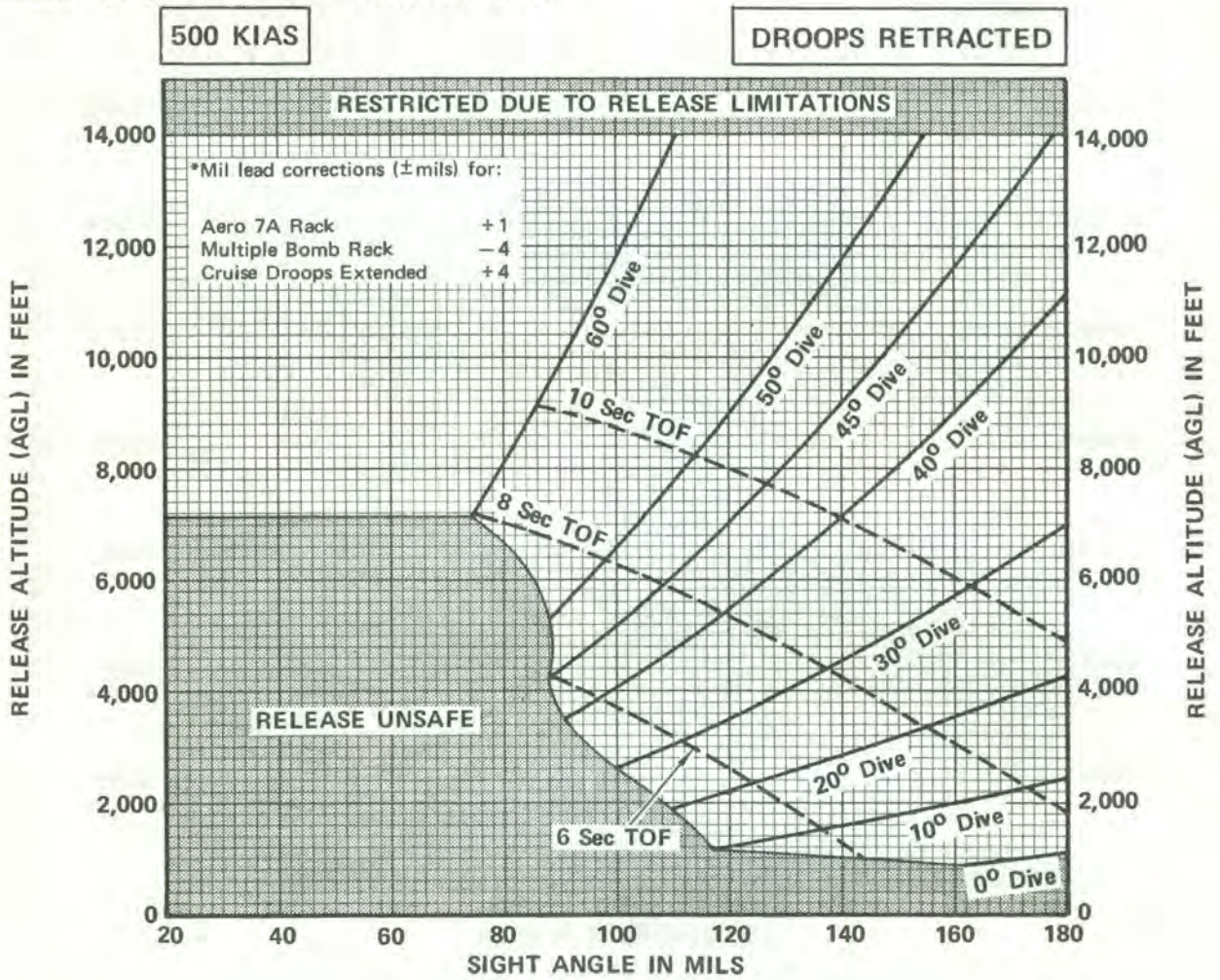
†Terrain avoidance is determining factor for this release altitude limitation.

AZ-216(3)-02-69

Figure 2-60 (Sheet 3)

Mil Lead for Single Delivery

MARK 82 SNAKEYE I – UNRETARDED



RELEASE ALTITUDES FOR SPECIFIED FRAGMENT HIT PROBABILITIES

DROP ANGLE	0.000 PROBABILITY	0.001 PROBABILITY	0.010 PROBABILITY
0°	790	760	670
10°	1,200	1,000	930
20°	1,900	1,630	1,550
30°	2,530	2,280	2,280†
40°	3,610	3,610†	3,610†
45°	4,270	4,270†	4,270†
50°	5,340	5,340†	5,340†
60°	7,040	7,040†	7,040†

NOTE

Sight angles are based on 27,000 lb aircraft gross weight, 0 ft burst altitude, 0 ft target elevation, and 5.6 ft/sec average ejection velocity. Released from MER or TER.

*For each 10°C increase (decrease) in release altitude temperature, increase (decrease) the mil lead by 3 mils.

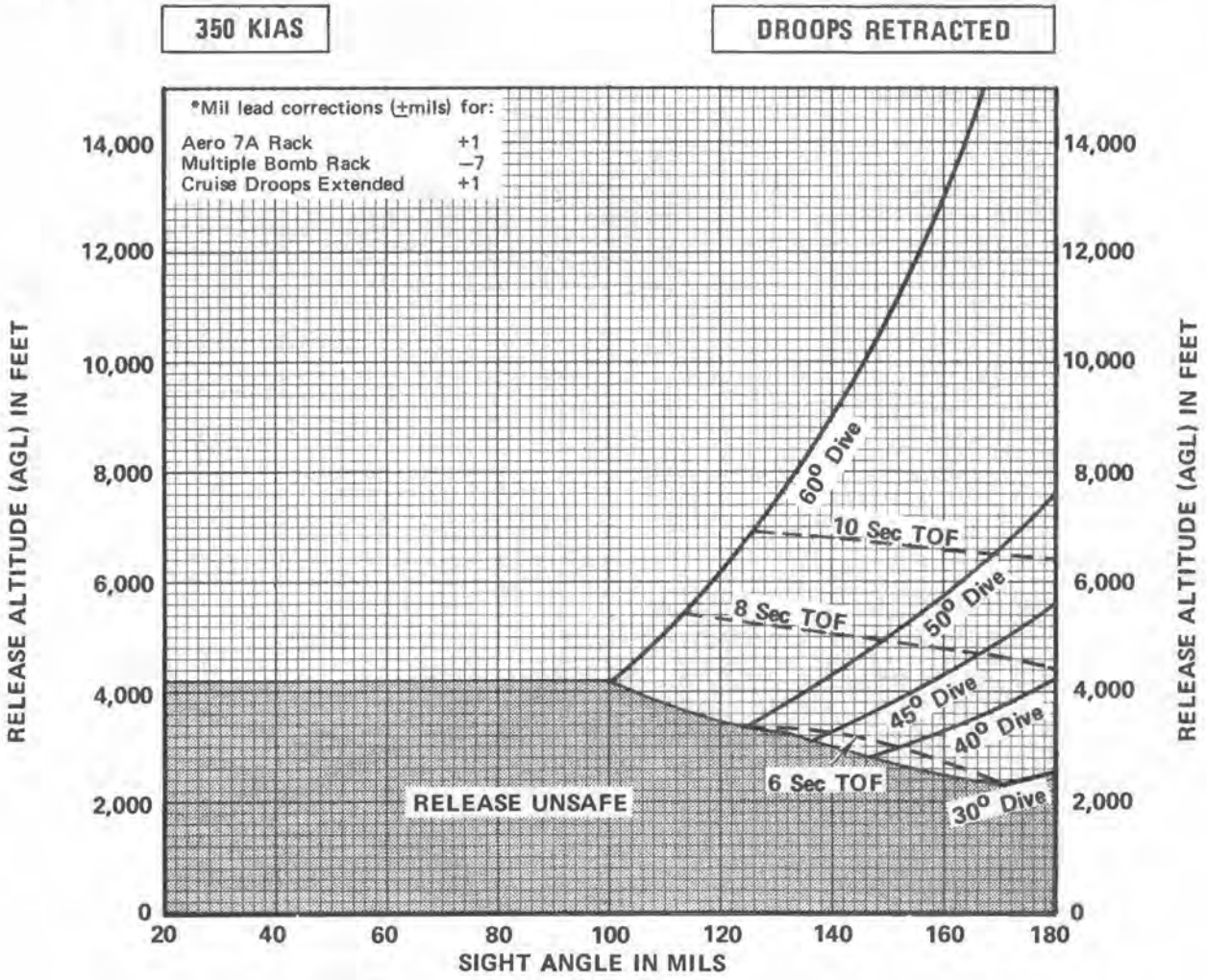
†Terrain avoidance is determining factor for this release altitude limitation.

AZ−216(4)−02−69

Figure 2–60 (Sheet 4)

Mil Lead for SingleDelivery

MK 82 CONICAL FIN



RELEASE ALTITUDES FOR SPECIFIED FRAGMENT HIT PROBABILITIES

DROP ANGLE	0.000 PROBABILITY	0.001 PROBABILITY	0.010 PROBABILITY
0°	1,570	1,230	1,010
10°	1,300	1,000	940
20°	1,720	1,410	1,360
30°	2,220	1,860	1,800
40°	2,650	2,300	2,290
45°	2,860	2,630	2,630†
50°	3,310	3,310†	3,310†
60°	4,150	4,150†	4,150†

NOTE

Sight angles are based on 27,000 lb aircraft gross weight, 0 ft burst altitude, 0 ft target elevation, and 6.0 ft/sec average ejection velocity. Released from MER or TER.

*For each 10° C increase (decrease) in release altitude temperature, increase (decrease) the mil lead by 3 mils.

†Terrain avoidance is determining factor for this release altitude limitation.

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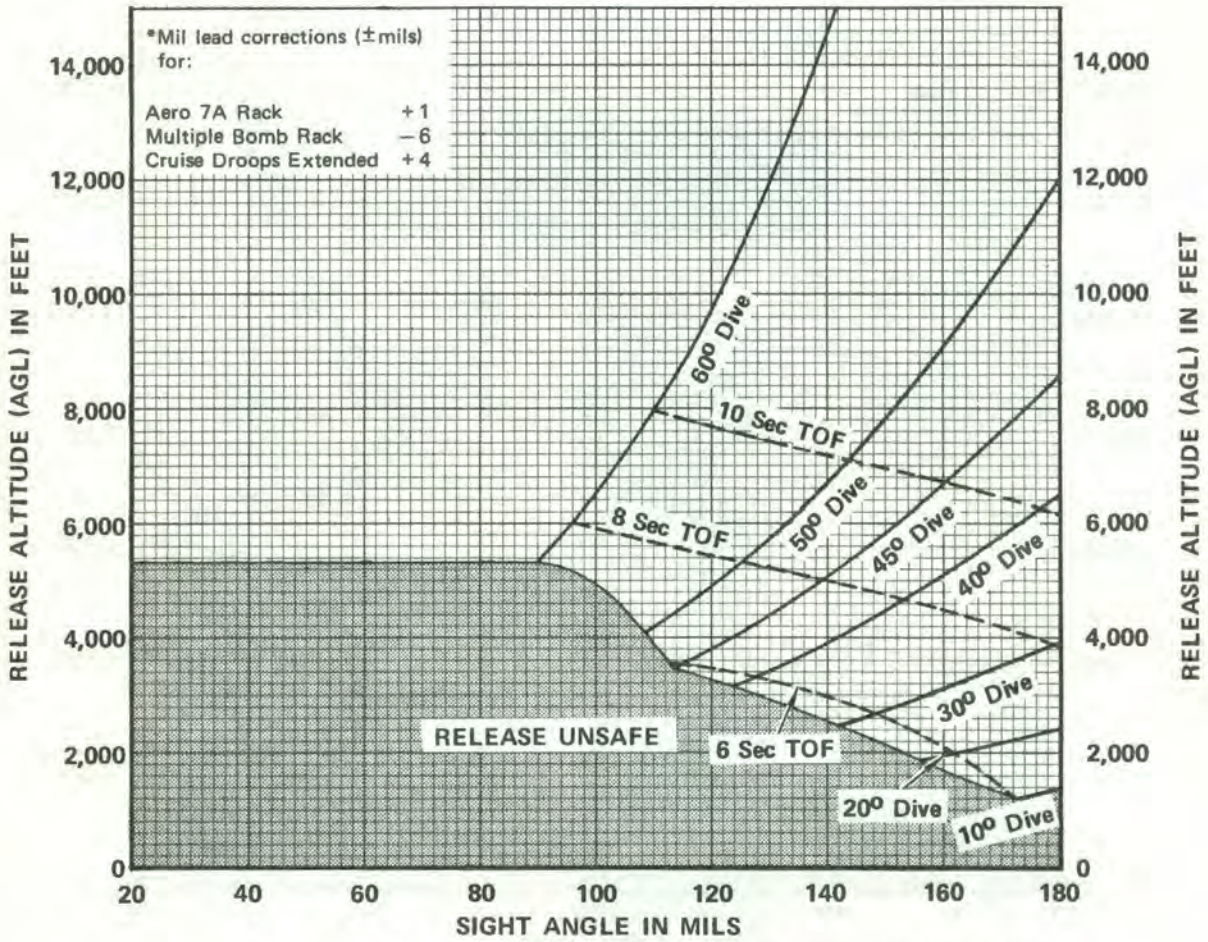
Figure 2-61 (Sheet 1)

Mil Lead for Single Delivery

MK 82 CONICAL FIN

400 KIAS

DROOPS RETRACTED



RELEASE ALTITUDES FOR SPECIFIED FRAGMENT HIT PROBABILITIES

DROP ANGLE	0.000 PROBABILITY	0.001 PROBABILITY	0.010 PROBABILITY
0°	1,390	1,090	950
10°	1,290	1,000	930
20°	1,820	1,510	1,430
30°	2,350	2,040	1,950
40°	2,890	2,690	2,690†
45°	3,130	3,130†	3,130†
50°	3,930	3,930†	3,930†
60°	5,040	5,040†	5,040†

NOTE

Sight angles are based on 27,000 lb aircraft gross weight, 0 ft burst altitude, 0 ft target elevation, and 6.0 ft/sec average ejection velocity. Released from MER or TER.

*For each 10° C increase (decrease) in release altitude temperature, increase (decrease) the mil lead by 3 mils.

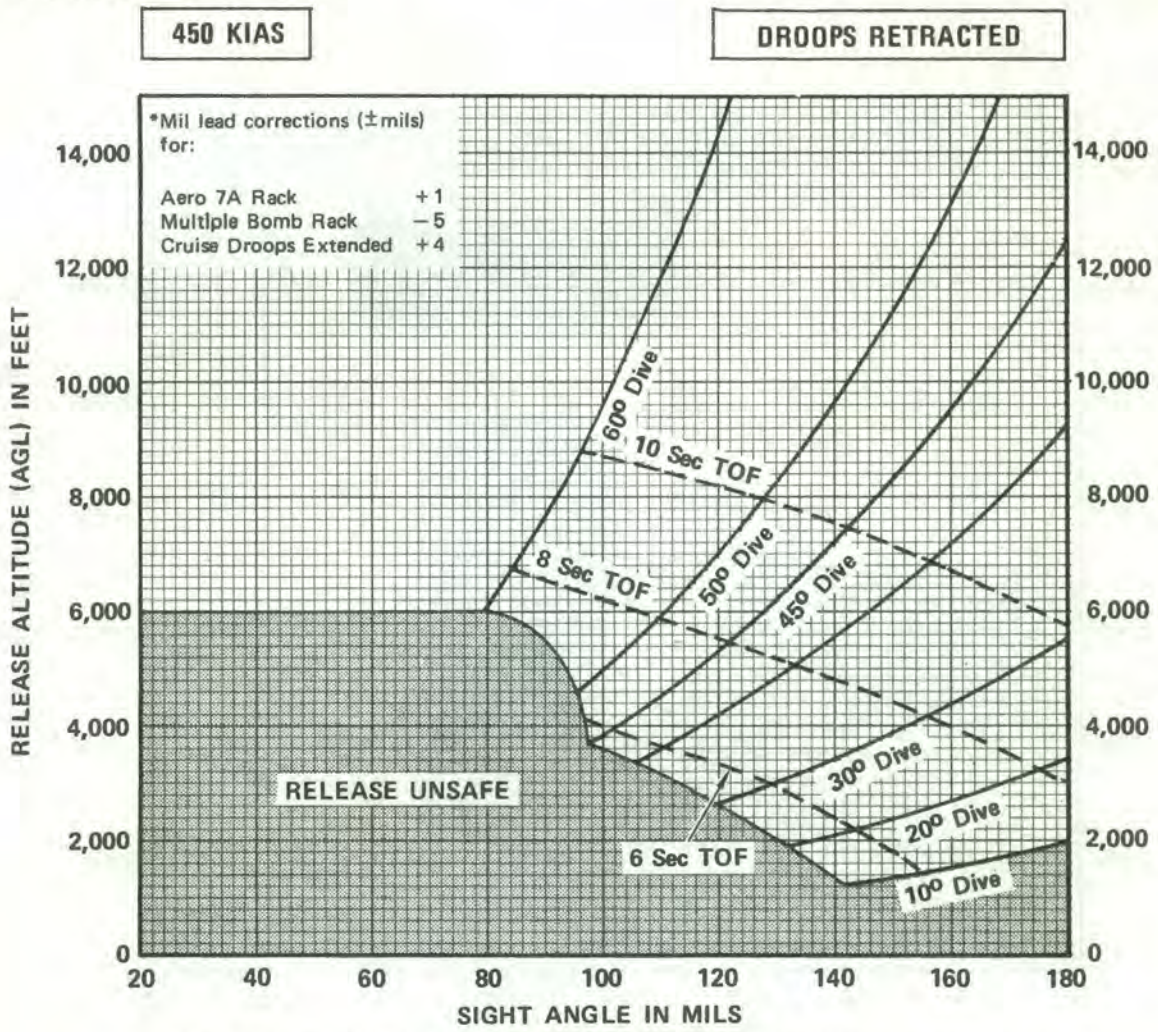
†Terrain avoidance is determining factor for this release altitude limitation.

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Figure 2-61 (Sheet 2)

Mil Lead for Single Delivery

MK 82 CONICAL FIN



RELEASE ALTITUDES FOR SPECIFIED FRAGMENT HIT PROBABILITIES

DROP ANGLE	0.000 PROBABILITY	0.001 PROBABILITY	0.010 PROBABILITY
0°	1,270	970	870
10°	1,210	1,020	960
20°	1,920	1,610	1,530
30°	2,530	2,200	2,090
40°	3,170	3,130	3,130†
45°	3,680	3,680†	3,680†
50°	4,610	4,610†	4,610†
60°	6,030	6,030†	6,030†

NOTE

Sight angles are based on 27,000 lb aircraft gross weight, 0 ft burst altitude, 0 ft target elevation, and 6.0 ft/sec average ejection velocity. Released from MER or TER.

*For each 10° C increase (decrease) in release altitude temperature, increase (decrease) the mil lead by 3 mils.

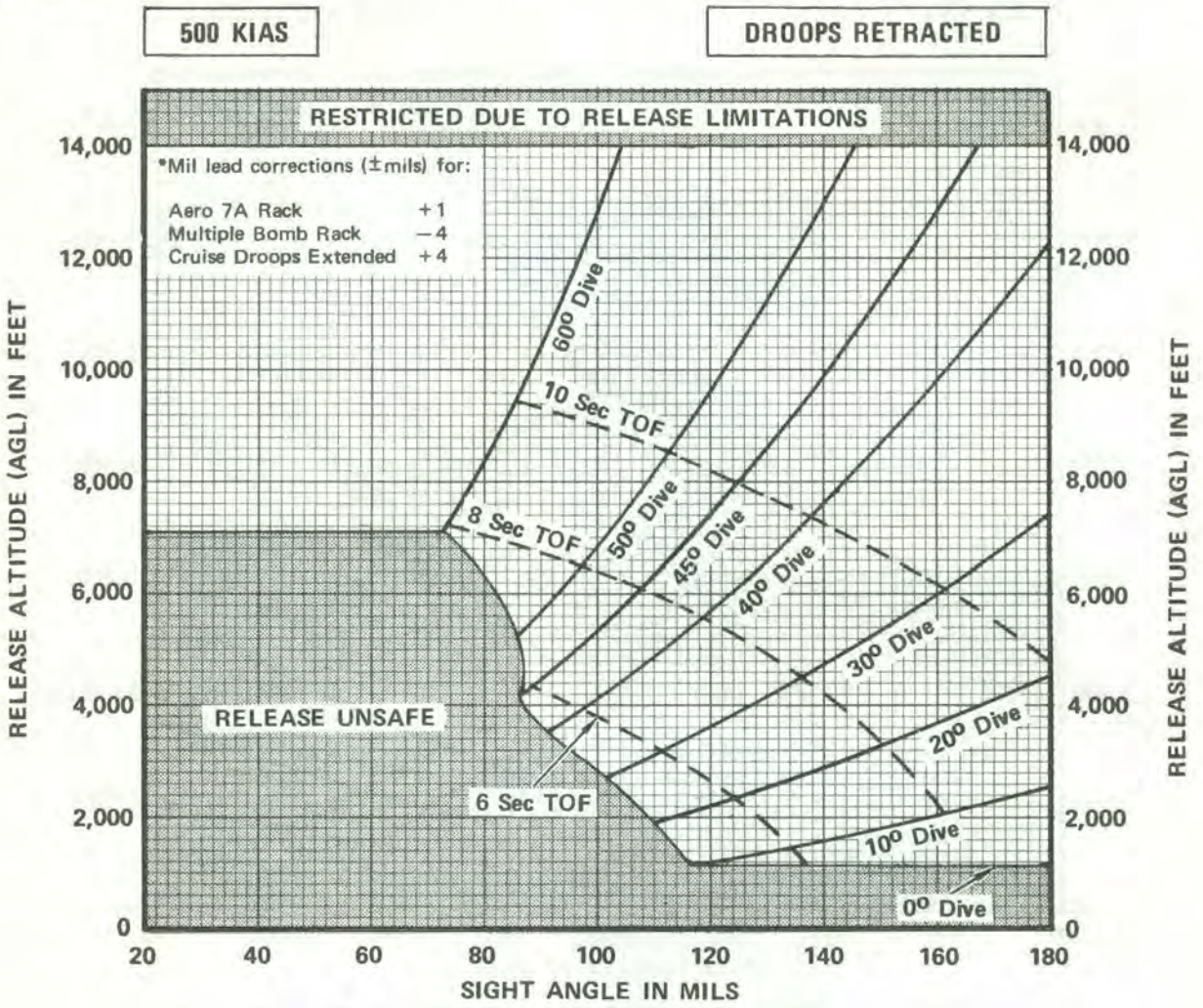
†Terrain avoidance is determining factor for this release altitude limitation.

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Figure 2-61 (Sheet 3)

Mil Lead for Single Delivery

MK 82 CONICAL FIN



RELEASE ALTITUDES FOR SPECIFIED FRAGMENT HIT PROBABILITIES

DROP ANGLE	0.000 PROBABILITY	0.001 PROBABILITY	0.010 PROBABILITY
0°	1,090	890	800
10°	1,300	1,050	990
20°	2,000	1,700	1,630
30°	2,670	2,330	2,280
40°	3,610	3,610†	3,610†
45°	4,270	4,270†	4,270†
50°	5,340	5,340†	5,340†
60°	7,040	7,040†	7,040†

NOTE

Sight angles are based on 27,000 lb aircraft gross weight, 0 ft burst altitude, 0 ft target elevation, and 6.0 ft/sec average ejection velocity.

Released from MER or TER.

*For each 10° C increase (decrease) in release altitude temperature, increase (decrease) the mil lead by 3 mils.

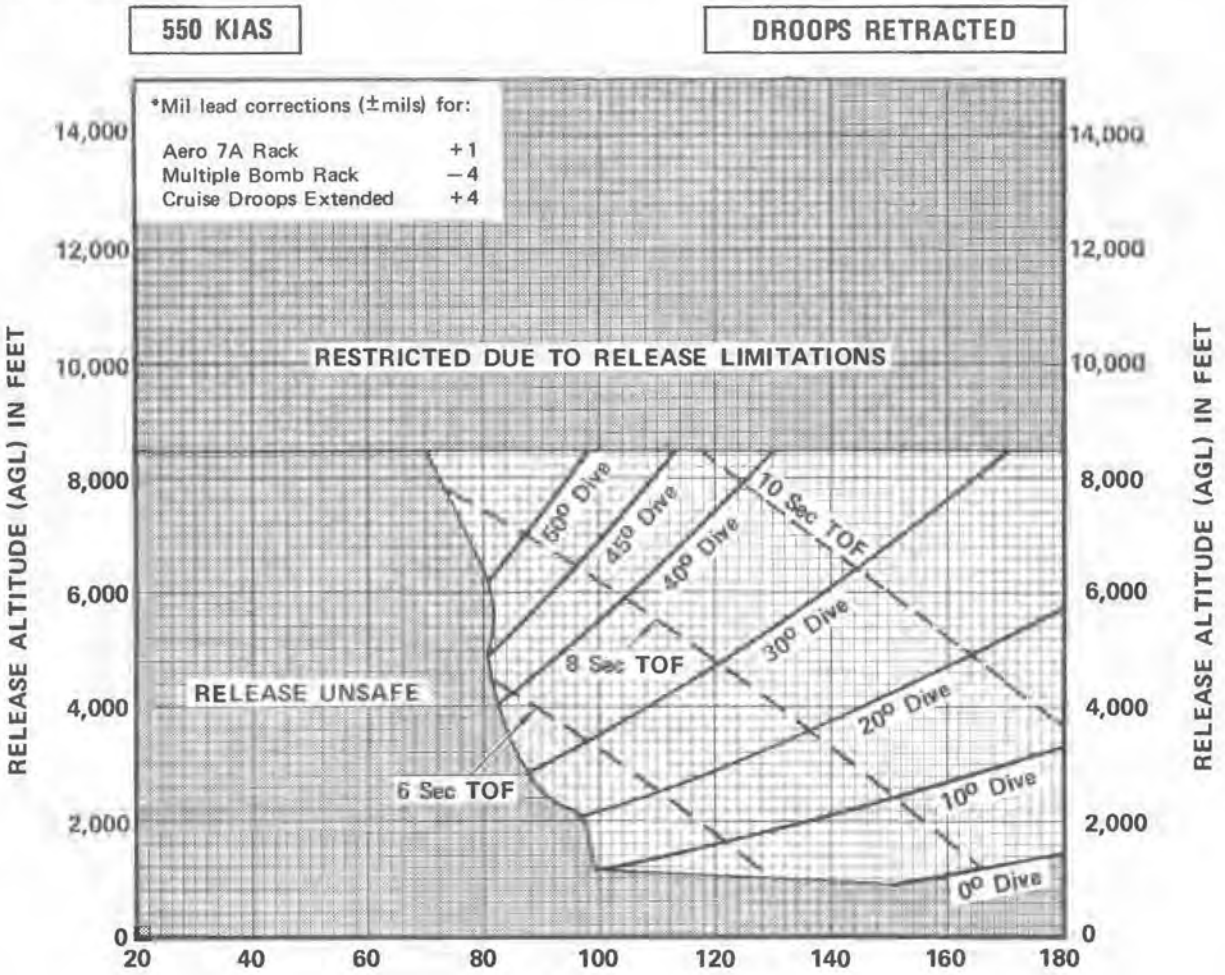
†Terrain avoidance is determining factor for this release altitude limitation.

AZ-217(4)-02-69

Figure 2-61 (Sheet 4)

Mil Lead for Single Delivery

MK 82 CONICAL FIN



RELEASE ALTITUDES FOR SPECIFIED FRAGMENT HIT PROBABILITIES

DROP ANGLE	0.000 PROBABILITY	0.001 PROBABILITY	0.010 PROBABILITY
0°	970	810	740
10°	1,300	1,090	1,030
20°	2,030	1,780	1,710
30°	2,840	2,570	2,570†
40°	4,080	4,080†	4,080†
45°	4,840	4,840†	4,840†
50°	6,000	6,000†	6,000†
60°	7,920	7,920†	7,920†

NOTE

Sight angles are based on 27,000 lb aircraft gross weight, 0 ft burst altitude, 0 ft target elevation, and 6.0 ft/sec average ejection velocity. Released from MER or TER.

*For each 10° C increase (decrease) in release altitude temperature, increase (decrease) the mil lead by 3 mils.

†Terrain avoidance is determining factor for this release altitude limitation.

AZ−217(5)−02−69

Figure 2–61 (Sheet 5)

Maximum Fragment Envelope

MK 82 GENERAL PURPOSE AND SNAKEYE I (RETARDED OR UNRETARDED)

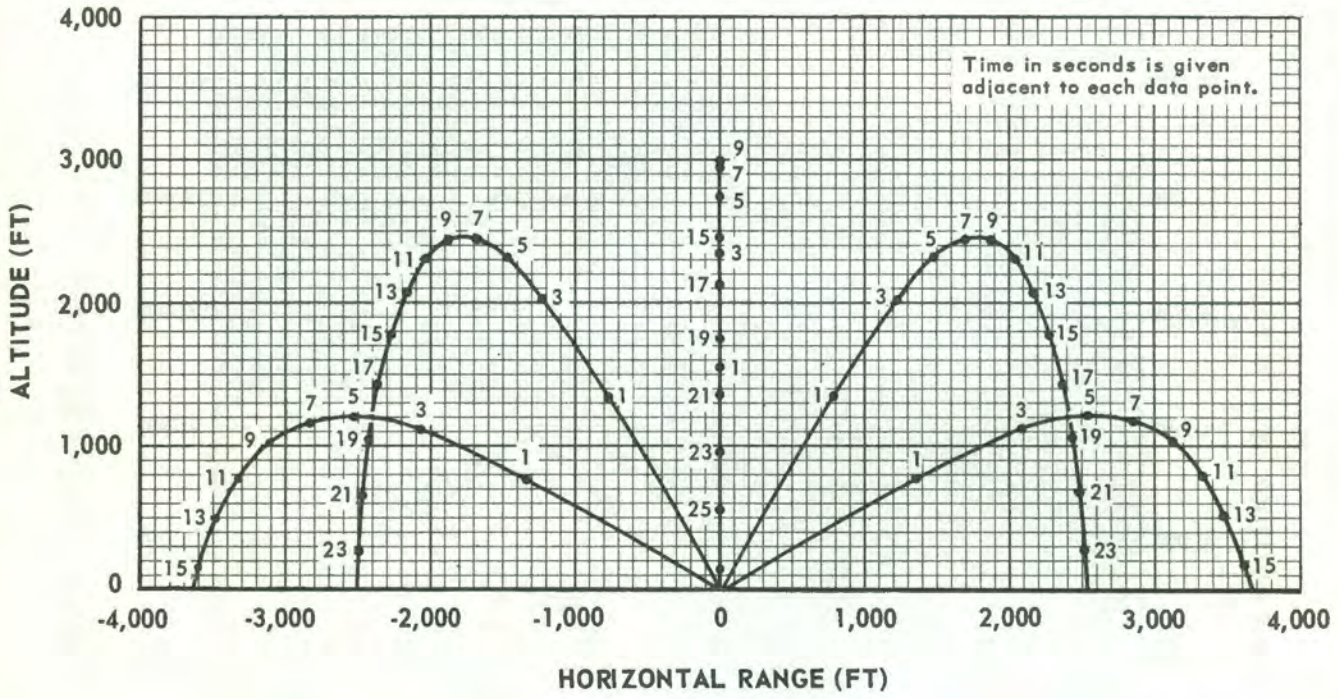


Figure 2–62

Tested Delivery Data

MK 82 CONICAL FIN

DIVE ANGLE	MIL LEAD		ENTRY			RELEASE			CORRECTION PER 10 KT OF DIRECT WIND – MILS		RELEASE ERROR SENSITIVITIES				
	EJECTED MILS	NON-EJECTED (MBR) – MILS	KIAS	ALTITUDE FT AGL	APPROX RPM %	KTAS	ALTITUDE FT AGL	ALTIMETER LAG – FT	Range	Cross	FT/KT KIAS	FT/100 FT ALTITUDE	FT/DEG DIVE ANGLE	FT/MIL RANGE	FT MIL DEFLECTION
30°	112	108	350	7,000	94	500	2,500	250	11	19	2	20	22	8	5
45°	113	108	250	10,000	86	450	3,500	0	16	20	2	10	15	6	5
45°	123	118	250	10,500	86	450	4,000	0	16	20	2	10	15	6	5

NOTES

1. Error sensitivities are applied as follows:

   Airspeed – Fast impacts long
   Slow impacts short

   Altitude – High impacts short
   Low impacts long

   Dive Angle – Steep impacts long
   Shallow impacts short

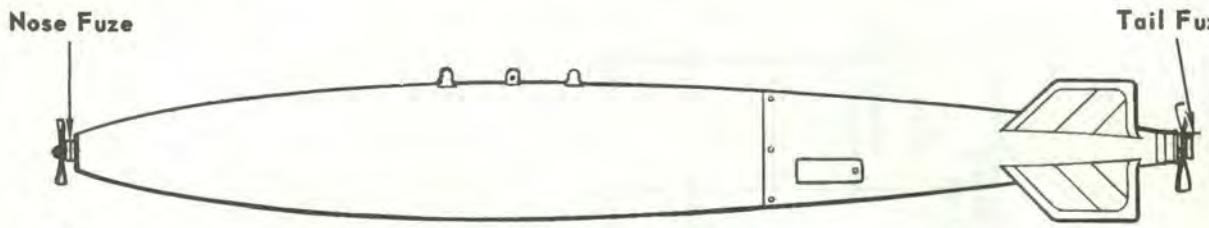
2. Mil lead computed for 28,000 lb aircraft with cruise droop extended.
   Correction – Add/subtract 1 mil for each 1,000 lb over/under 28,000 lb.

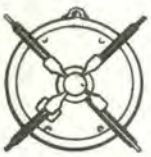
3. 45° dive profiles flown with speed brakes OUT.

AZ-243-2-67

Figure 2–63

MK 83 GP Bomb





PHYSICAL CHARACTERISTICS

Weight Loaded – 985 pounds
Length – 118.42 inches
Diameter – 14 inches
Suspension lugs – 14 inches apart

DESCRIPTION

The MK 83 bomb is a 1000-pound general purpose bomb normally used for demolition operation. The bomb was designed to produce minimum drag featuring a slender body with a conical fin.

WING STATION LOADING CONFIGURATIONS	
WING LOADING	**EQUIPMENT-WEIGHT**
AERO 7A-1 SUSPENSION **One Bomb Each Wing** 	2 MK 83 1970 2 Aero 7A-1 104 2 Pylons 350 Total 2424 One Wing Only 1212
TER SUSPENSION **Two Bombs Each Wing** 	4 MK 83 3940 2 TER 210 2 Aero 7A-1 104 2 Pylons 350 Total 4604 One Wing Only 2302
MER SUSPENSION **Two Bombs Each Wing** 	4 MK 83 3940 2 MER 446 2 Aero 7A-1 104 2 Pylons 350 Total 4840 One Wing Only 2420

DROPPING PROCEDURE	DROPPING PROCEDURE
(Mechanical Fuzing) 1. Master Arm Sw – ON 2. Armament Sel Sw – Wing L or R 3. Mechanical Fuzing Sw – NOSE or TAIL 4. Stores Release Sw – DEPRESS	(Electrical Fuzing) 1. Master Arm Sw – ON 2. Armament Sel Sw – Wing L or R 3. Option Sel Sw – As Desired 4. Safe-Stby-Ready Sw (AWW-1) – STBY for 30 sec then RDY 5. HV DC light – ON 6. Stores Release Sw – DEPRESS

NOTE

For simultaneous release from the Aero 7A-1 racks, the Triple-Multiple Rack Fire Mode switch must be set to the DUAL position and the Arm Sel Sw in the WING, L position.

To step the MER or TER stepping switch past an empty station, it is necessary to have the hooks at that station open or the stores release switch must be depressed and released once for each empty station between bombs. With the -501 or -521 TER or MER, the mechanical fuzing switch must also be placed in the NOSE position to obtain automatic stepping past empty stations.

JETTISONING PROCEDURES

See JETTISONING this section.

REFERENCES

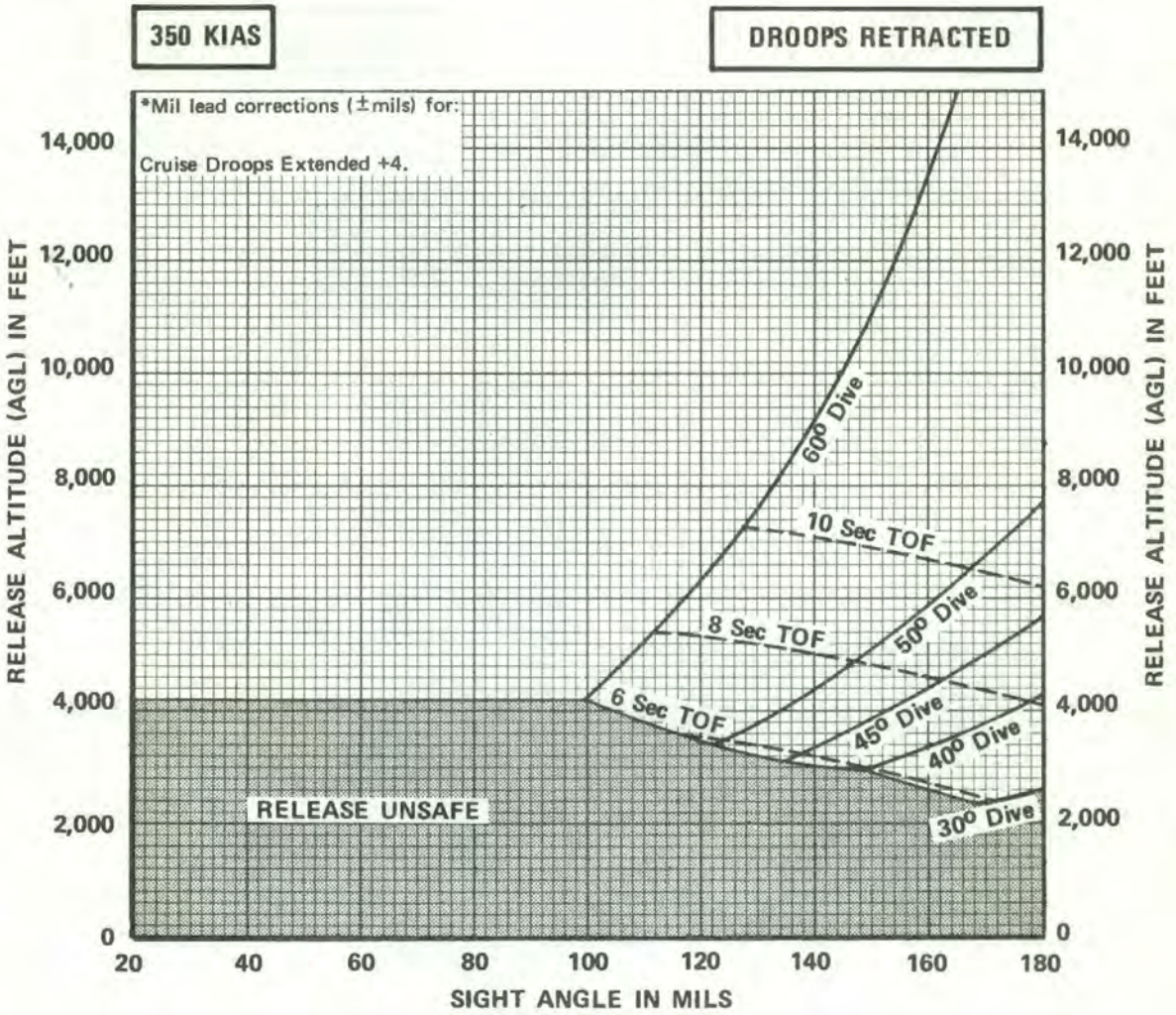
1. Restrictions – See Figure 2-2
2. Bomb Fuzing – NAVAIR 11-5A-17 (OP 2216)
3. Preflight Inspection – NAVAIR 01-45HH-75
4. Bomb Loading Procedures – NAVAIR 01-45HH-75

AZ-94-03-69

Figure 2-64

Mil Lead for Single Delivery

MK 83 CONICAL FIN



RELEASE ALTITUDES FOR SPECIFIED FRAGMENT HIT PROBABILITIES

DROP ANGLE	0.000 PROBABILITY	0.001 PROBABILITY	0.010 PROBABILITY
0°	1,680	1,580	1,180
10°	1,300	1,260	1,030
20°	1,800	1,710	1,490
30°	2,240	2,190	1,940
40°	2,750	2,670	2,390
45°	2,960	2,890	2,630
50°	3,310	3,310†	3,310†
60°	4,150	4,150†	4,150†

NOTE

Sight angles are based on 27,000 lb aircraft gross weight, 0 ft burst altitude, 0 ft target elevation, and 5 ft/sec ejection velocity. Release from MER, TER, or Aero 7A EBR.

*For each 10° C increase (decrease) in release altitude temperature, increase (decrease) mil lead by 3 mils.

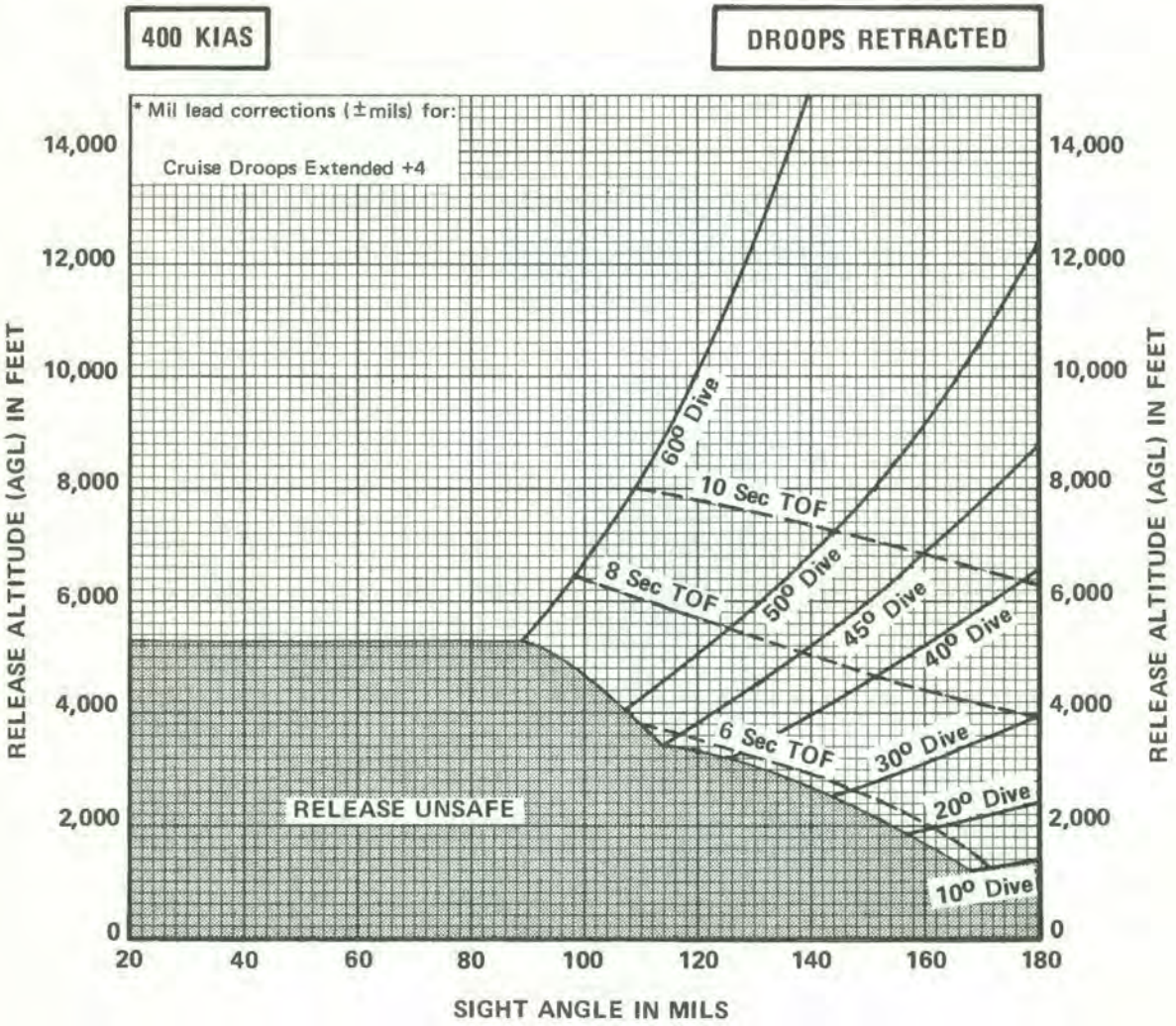
†Terrain avoidance is determinging factor for this release altitude limitation.

AZ-218(1)-3-69

Figure 2-65 (Sheet 1)

Mil Lead for Single Delivery

MK 83 CONICAL FIN



RELEASE ALTITUDES FOR SPECIFIED FRAGMENT HIT PROBABILITIES

DROP ANGLE	0.000 PROBABILITY	0.001 PROBABILITY	0.010 PROBABILITY
0°	1,570	1,420	1,090
10°	1,300	1,250	1,060
20°	1,820	1,790	1,590
30°	2,430	2,360	2,130
40°	2,960	2,930	2,690
45°	3,200	3,180	3,130
50°	3,930	3,930†	3,930†
60°	5,040	5,040†	5,040†

NOTE

Sight angles are based on 27,000 lb aircraft gross weight, 0 ft burst altitude, 0 ft target elevation, and 5 ft/sec ejection velocity. Released from MER, TER or Aero 7A EBR

* For each 10° C increase (decrease) in release altitude temperature increase (decrease) mil lead by 3 mils.

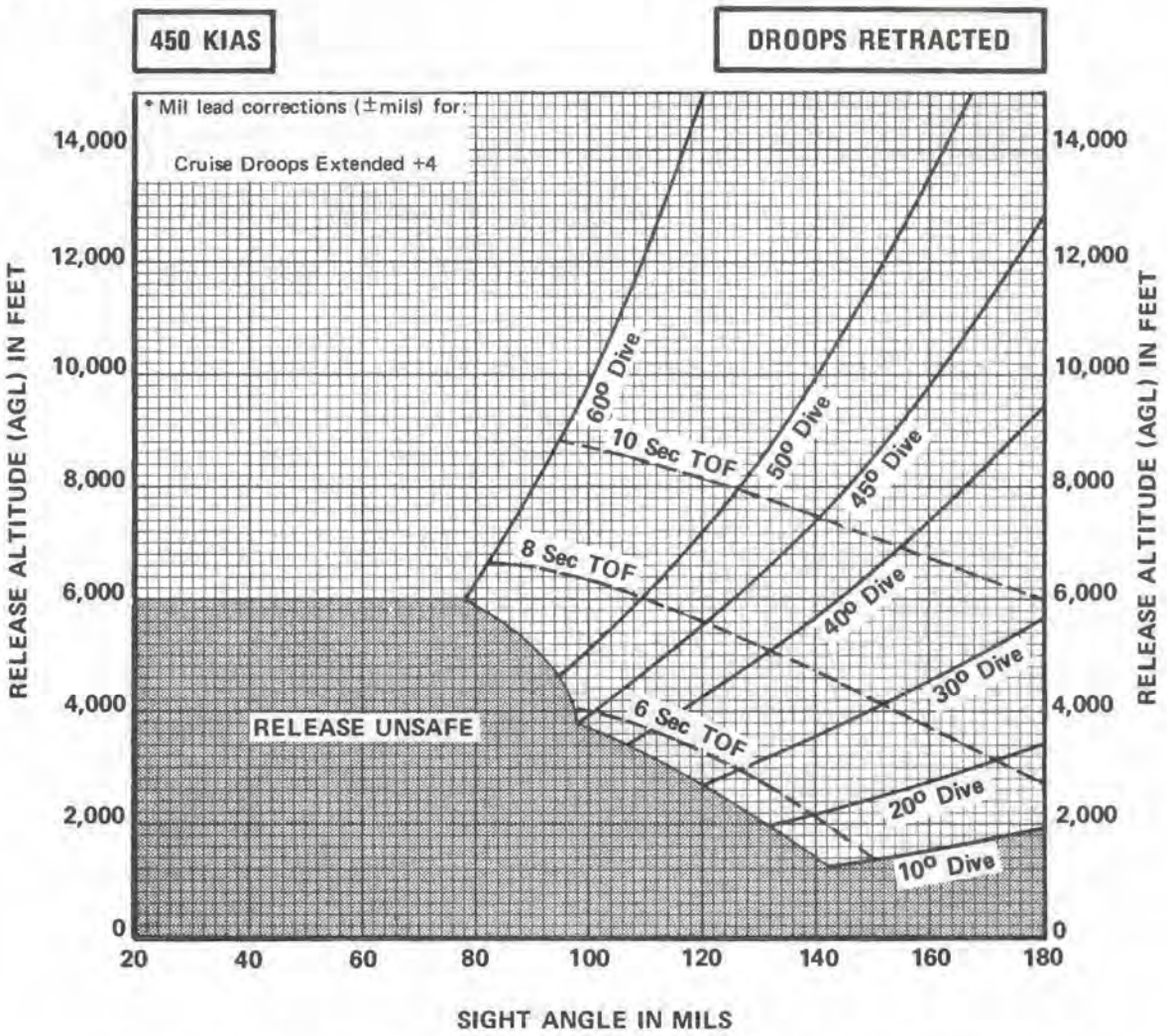
† Terrain avoidance is determining factor for this release altitude limitation.

AZ-218(2)-3-69

Figure 2-65 (Sheet 2)

Mil Lead for Single Delivery

MK 83 CONICAL FIN



RELEASE ALTITUDES FOR SPECIFIED FRAGMENT HIT PROBABILITIES

DROP ANGLE	0.000 PROBABILITY	0.001 PROBABILITY	0.010 PROBABILITY
0°	1,380	1,280	1,010
10°	1,300	1,250	1,090
20°	1,920	1,890	1,700
30°	2,560	2,540	2,300
40°	3,210	3,160	3,130
45°	3,680	3,680†	3,680†
50°	4,610	4,610†	4,610†
60°	6,030	6,030†	6,030†

NOTE

Sight angles are based on 27,000 lb aircraft gross weight, 0 ft burst altitude, 0 ft target elevation, and 5 ft/sec ejection velocity. Release from MER, TER or Aero 7A EBR

* For each 10° C increase (decrease) in release altitude temperature increase (decrease) mil lead by 3 mils.

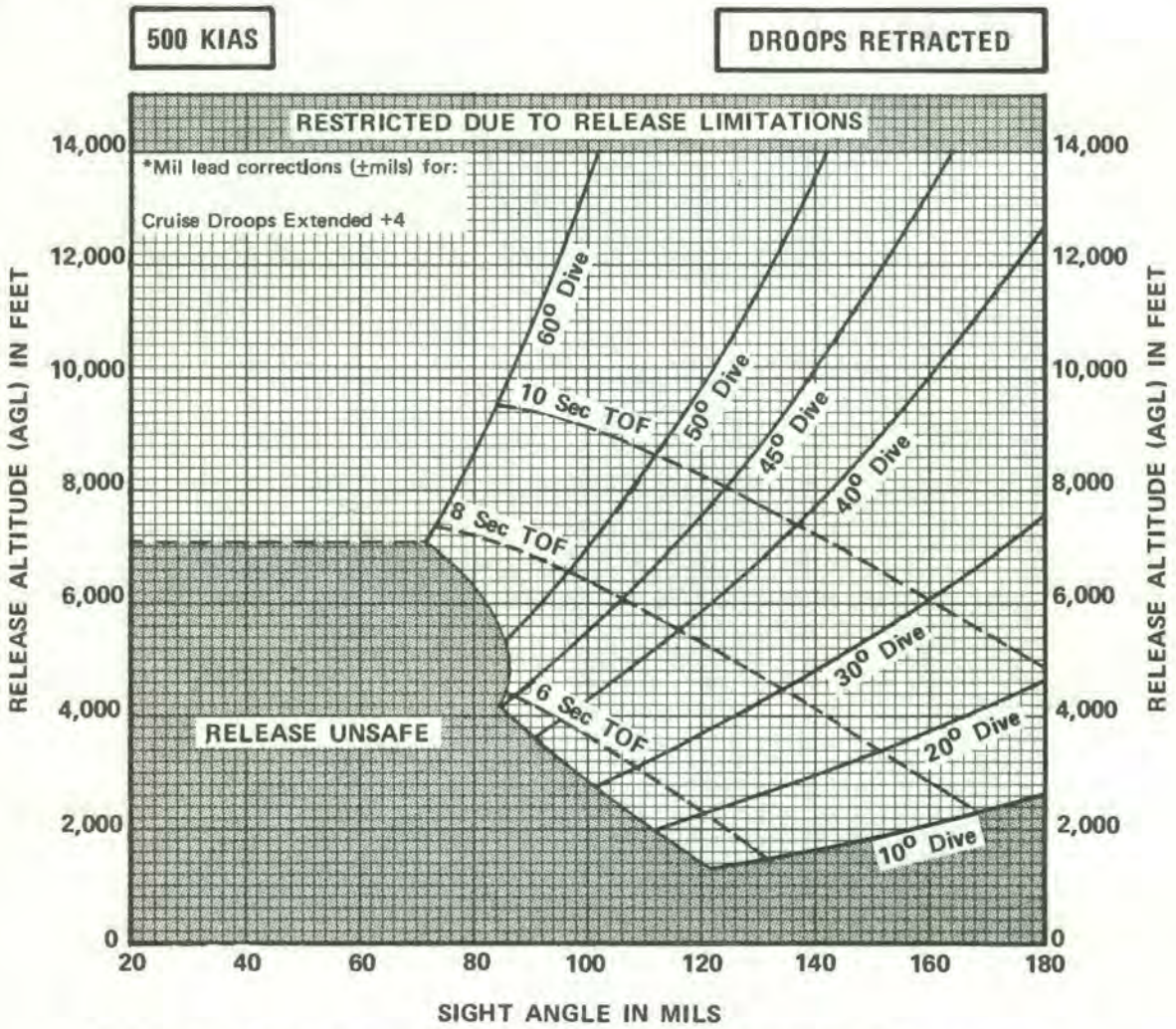
† Terrain avoidance is determining factor for this release altitude limitation.

AZ-218(3)-3-69

Figure 2-65 (Sheet 3)

Mil Lead for Single Delivery

MK 83 CONICAL FIN



RELEASE ALTITUDES FOR SPECIFIED FRAGMENT HIT PROBABILITIES

DROP ANGLE	0.000 PROBABILITY	0.001 PROBABILITY	0.010 PROBABILITY
0°	1,280	1,160	920
10°	1,320	1,270	1,110
20°	2,050	2,000	1,800
30°	2,770	2,730	2,470
40°	3,610	3,610†	3,610†
45°	4,270	4,270†	4,270†
50°	5,340	5,340†	5,340†
60°	7,040	7,040†	7,040†

NOTE

Sight angles are based on 27,000 lb aircraft gross weight, 0 ft burst altitude, 0 ft target elevation, and 5 ft/sec ejection velocity. Released from MER, TER or Aero 7A EBR

*For each 10°C increase (decrease) in release altitude temperature increase (decrease) mil lead by 3 mils.

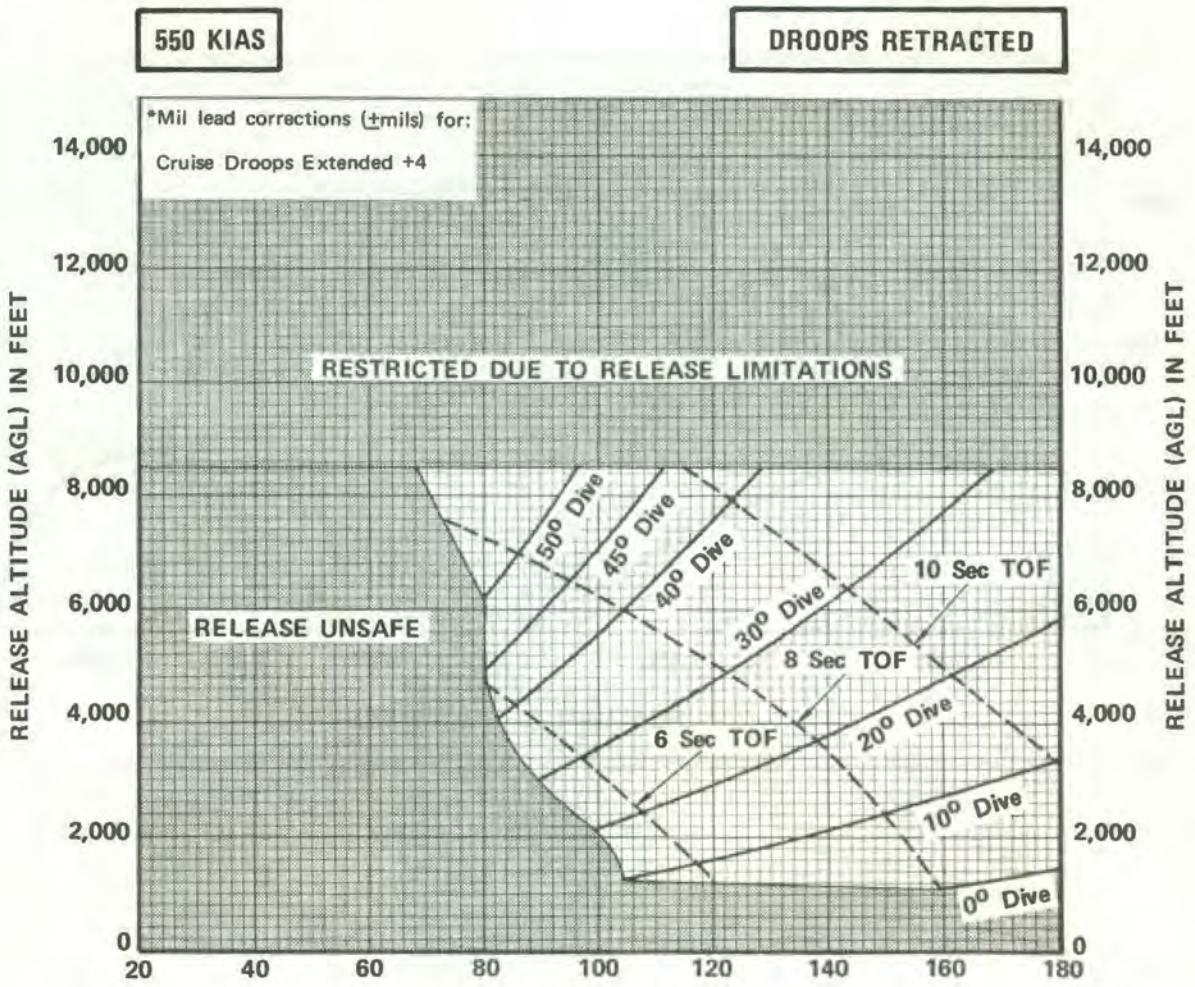
†Terrain avoidance is determing factor for this release altitude limitation.

AZ-218(4)-3-69

Figure 2-65 (Sheet 4)

Mil Lead for Single Delivery

MK 83 CONICAL FIN



RELEASE ALTITUDES FOR SPECIFIED FRAGMENT HIT PROBABILITIES

DROP ANGLE	0.000 PROBABILITY	0.001 PROBABILITY	0.010 PROBABILITY
0°	1,170	1,000	850
10°	1,400	1,290	1,150
20°	2,230	2,110	1,910
30°	2,980	2,900	2,640
40°	4,080	4,080†	4,080†
45°	4,840	4,840†	4,840†
50°	6,000	6,000†	6,000†
60°	7,920	7,920†	7,920†

NOTE

Sight angles are based on 27,000 lb aircraft gross weight, 0 ft burst altitude, 0 ft target elevation, and 5.0 ft sec ejection velocity. Release from MER, TER or Aero 7A EBR

*For each 10°C increase (decrease) in release altitude temperature increase (decrease) mil lead by 3 mils.

†Terrain avoidance is determining factor for this release altitude limitation.

AZ-218(5)-3-69

Figure 2-65 (Sheet 5)

Maximum Fragment Envelope

MK 83 GENERAL PURPOSE BOMB

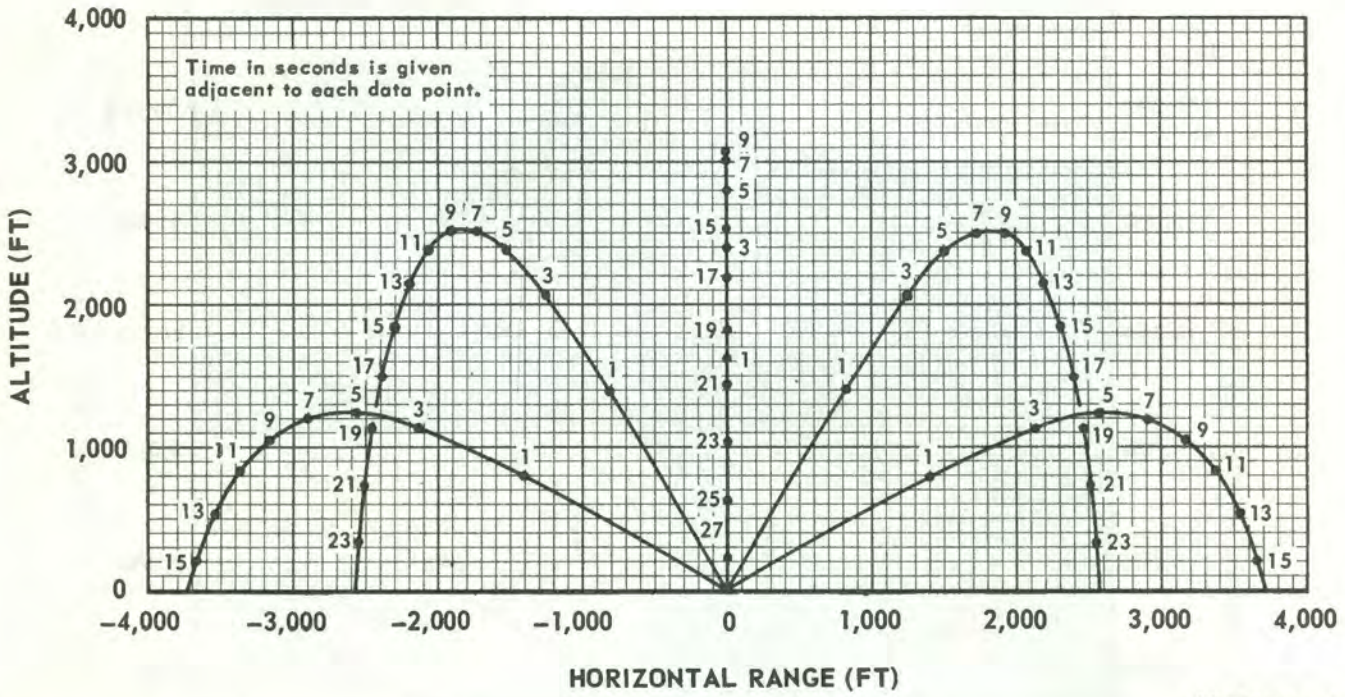


Figure 2–66

MK 83 CONICAL FIN

DIVE ANGLE	MIL LEAD		ENTRY			RELEASE			CORRECTION PER 10 KT OF DIRECT WIND – MILS		RELEASE ERROR SENSITIVITIES				
	EJECTED MILS	NON-EJECTED (MBR) – MILS	KIAS	ALTITUDE FT AGL	APPROX RPM %	KTAS	ALTITUDE FT AGL	ALTIMETER LAG – FT	Range	Cross	FT/KT KIAS	FT/100 FT ALTITUDE	FT/DEG DIVE ANGLE	FT/MIL RANGE	FT/MIL DEFLECTION
30°	123	NA	350	7,500	94	500	3,000	250	11	19	2	20	22	8	5
45°	120	NA	250	10,500	96	450	4,000	0	16	20	2	10	15	6	5

NOTES

1. Error sensitivities are applied as follows:

   Airspeed – Fast impacts long
   Slow impacts short

   Altitude – High impacts short
   Low impacts long

   Dive Angle – Steep impacts long
   Shallow impacts short

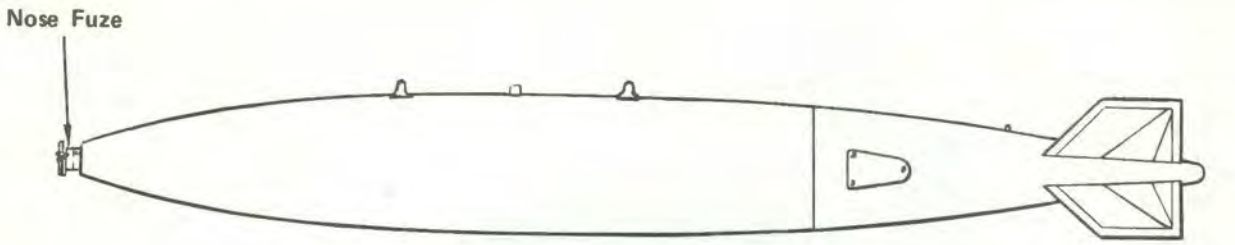
2. Mil lead computed for 28,000 lb aircraft with cruise droop extended.
   Correction – Add/subtract 1 mil for each 1,000 lb over/under 28,000 lb.

3. 45° dive profiles flown with speed brakes OUT.

AZ–244–2–67

Figure 2–67

MK 84 GP Bomb





PHYSICAL CHARACTERISTICS

Weight	– 1970 pounds
Length	– 151.5 inches
Diameter	– 18 inches
Suspension lugs	– 30 inches apart

DESCRIPTION

The Mk 84 bomb is a 2000-pound general purpose bomb normally used for demolition operation. The bomb was designed to produce minimum drag by using a slender body, a long nose, and a conical fin.

DROPPING PROCEDURE

(Mechanical Fuzing)

1. Master Arm Sw – ON
2. Armament Sel Sw – Wing L or R
3. Mechanical Fuzing Sw – NOSE or TAIL
4. Stores Release Sw – DEPRESS

DROPPING PROCEDURE

(Electrical Fuzing)

1. Master Arm Sw – ON
2. Armament Sel Sw – Wing L or R
3. Option Sel Sw (AWW-1) – As Desired
4. Safe-Stdy-Ready Sw (AWW-1) – STDY for 30 seconds then RDY
5. HV DC Light (AWW-1) – ON
6. Stores Release Sw – DEPRESS

WING STATION LOADING CONFIGURATION

WING LOADING	EQUIPMENT-WEIGHT
AERO 7A SUSPENSION One Bomb Each Wing	2 MK 84 3940 2 Aero 7A-1 104 2 Pylons 350 Total 4394 One Wing Only 2197



NOTE

For simultaneous release from the Aero 7A-1 racks the Triple-Multiple Rack Fire Mode switch in each pylon must be set to the DUAL position.

JETTISONING PROCEDURES

See JETTISONING this section.

REFERENCES

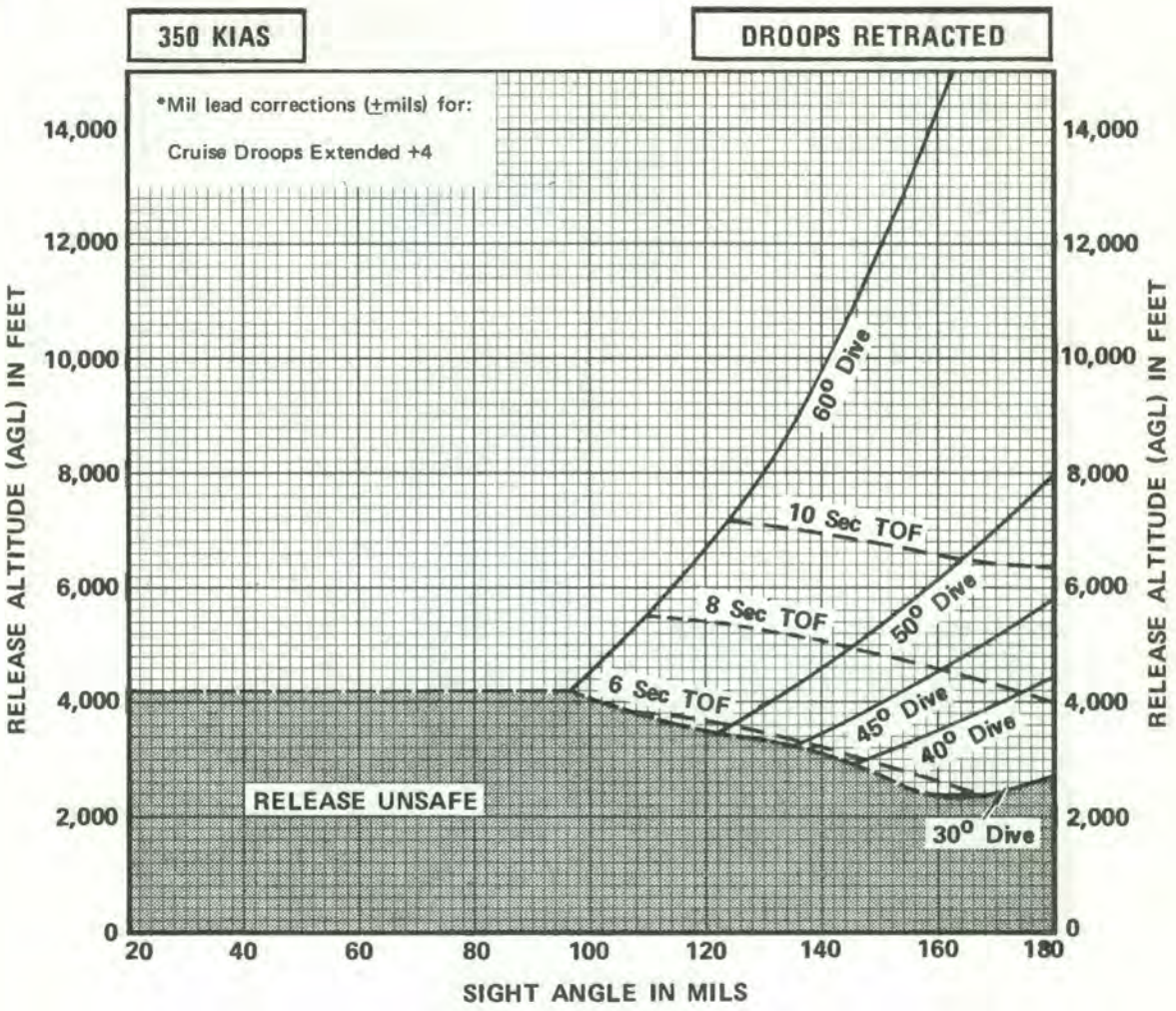
1. Restrictions – See Figure 2-2
2. Bomb Fuzing – NAVAIR 11-5A-17 (OP 2216)
3. Preflight Inspection – NAVAIR 01-45HH-75
4. Bomb Loading Procedures – NAVAIR 01-45HH-75

AZ-95-03-70

Figure 2-68 (U)

Mil Lead for Single Delivery

MK 84 CONICAL FIN



RELEASE ALTITUDES FOR SPECIFIED FRAGMENT HIT PROBABILITIES

DROP ANGLE	0.000 PROBABILITY	0.001 PROBABILITY	0.010 PROBABILITY
0°	1,680		
10°	1,310		
20°	1,800		
30°	2,240		
40°	2,750		
45°	2,960		
50°	3,310		
60°	4,150		

NOTE

Sight angles are based on 27,000 lb aircraft gross weight, 0 ft burst altitude, 0 ft target elevation, and 3 ft/sec ejection velocity. Released from Aero 7A EBR. Fragmentation data estimated from Mk 81, 82 and 83 general purpose low drag bombs.

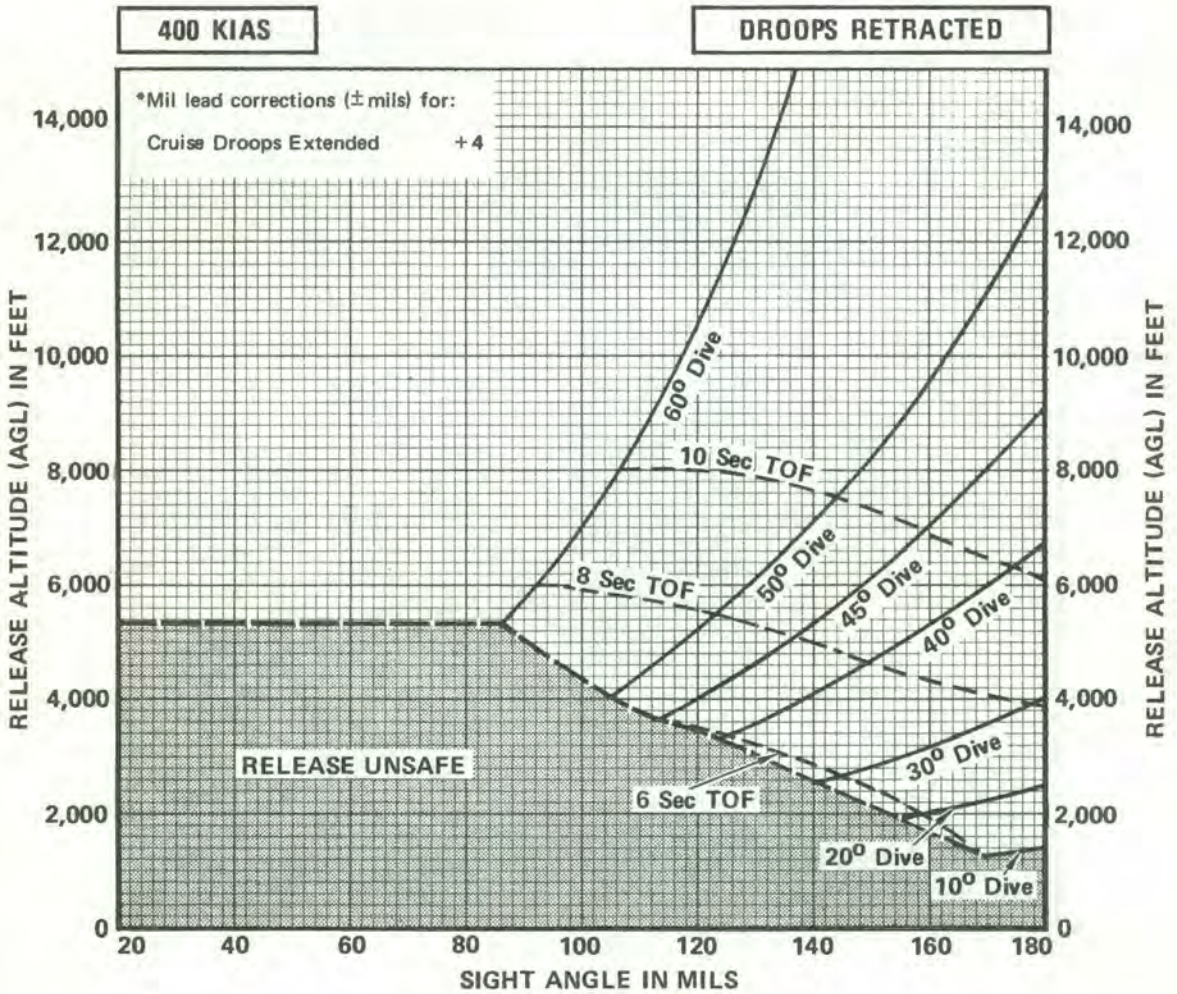
*For each 10° C increase (decrease) in release altitude temperature, increase (decrease) mil lead by 3 mils.

AZ-219(1)-03-69

Figure 2-69 (Sheet 1)

Mil Lead for Single Delivery

MK 84 CONICAL FIN



RELEASE ALTITUDES FOR SPECIFIED FRAGMENT HIT PROBABILITIES

DROP ANGLE	0.000 PROBABILITY	0.001 PROBABILITY	0.010 PROBABILITY
0°	1,580		
10°	1,390		
20°	1,820		
30°	2,450		
40°	2,960		
45°	3,200		
50°	3.930		
60°	5,040		

NOTE

Sight angles are based on 27,000 lb aircraft gross weight, 0 ft burst altitude, 0 ft target elevation, and 3 ft/sec ejection velocity. Released from Aero 7A EBR. Fragmentation data estimated from Mk 81, 82 and 83 general purpose low drag bombs.

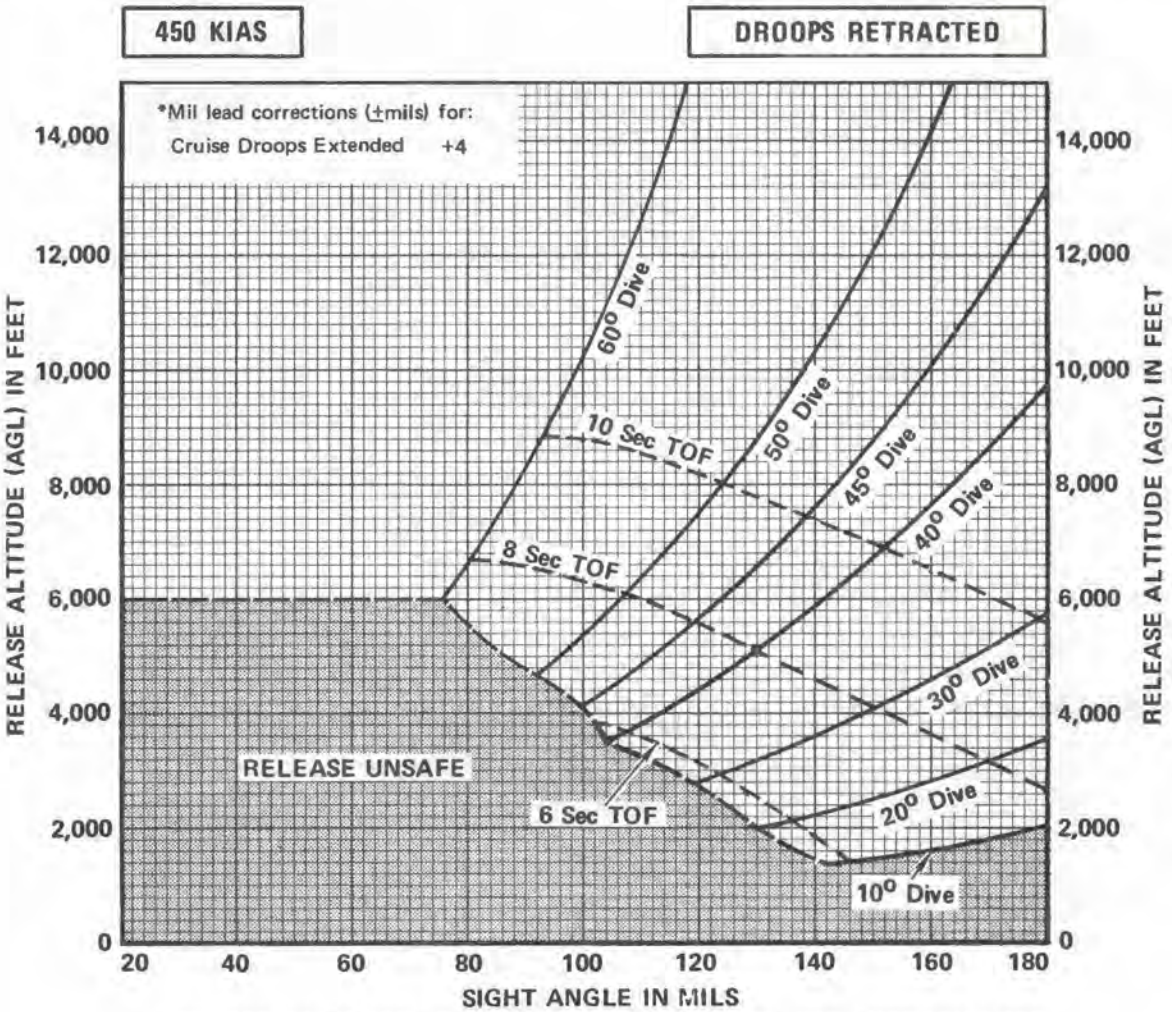
*For each 10° C increase (decrease) in release altitude temperature, increase (decrease) mil lead by 3 mils.

AZ-219(2)-03-69

Figure 2-69 (Sheet 2)

Mil Lead for Single Delivery

MK 84 CONICAL FIN



RELEASE ALTITUDES FOR SPECIFIED FRAGMENT HIT PROBABILITIES

DROP ANGLE	0.000 PROBABILITY	0.001 PROBABILITY	0.010 PROBABILITY
0°	1,470		
10°	1,300		
20°	1,950		
30°	2,630		
40°	3,210		
45°	3,680		
50°	4,610		
60°	6,030		

NOTE

Sight angles are based on 27,000 lb aircraft gross weight, 0 ft burst altitude, 0 ft target elevation, and 3 ft/sec ejection velocity. Released from Aero 7A EBR. Fragmentation data estimated from Mk 81, 82 and 83 general purpose low drag bombs.

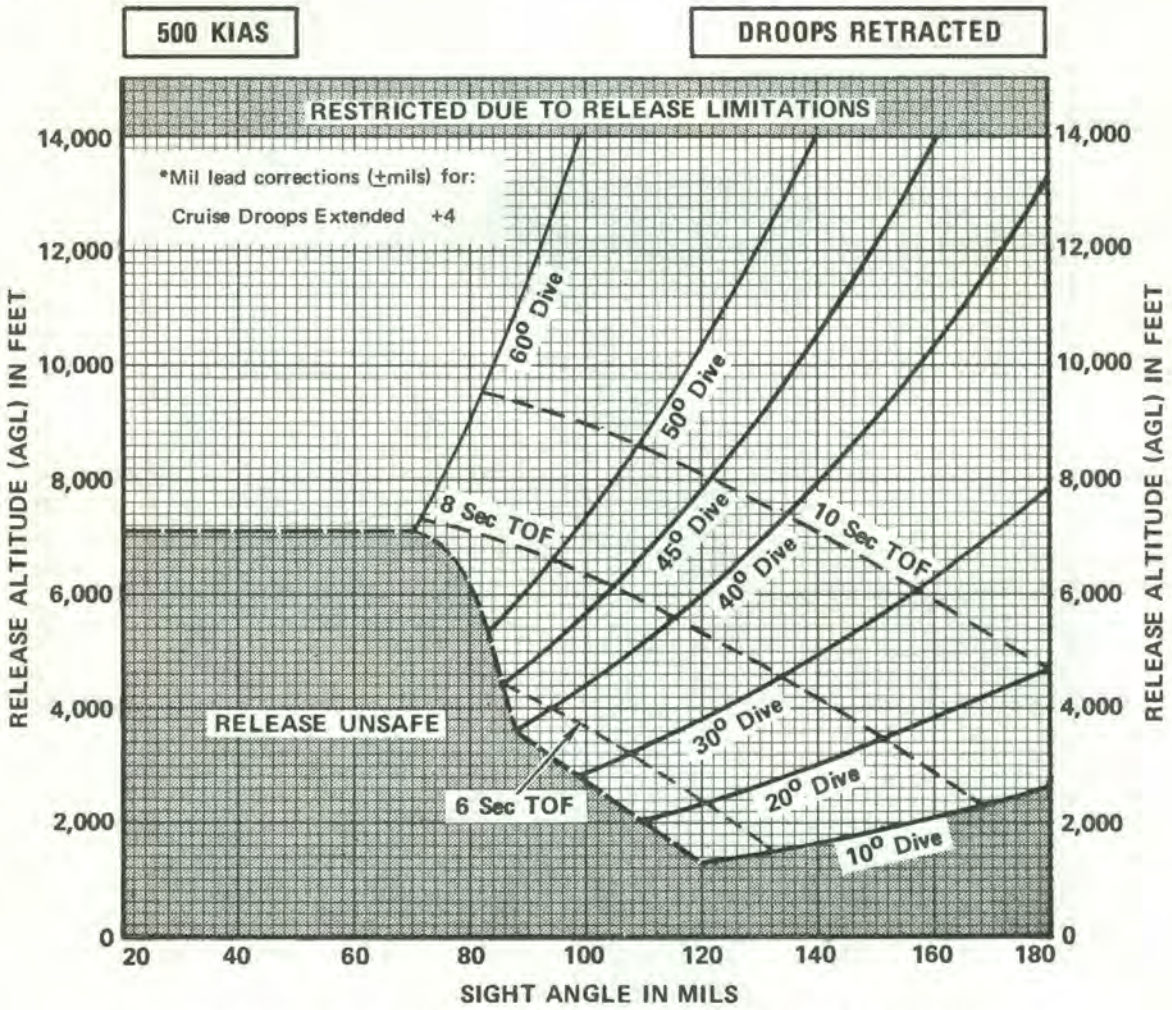
*For each 10° C increase (decrease) in release altitude temperature, increase (decrease) mil lead by 3 mils.

AZ-219(3)-03-69

Figure 2-69 (Sheet 3)

Mil Lead for Single Delivery

MK 84 CONICAL FIN



RELEASE ALTITUDES FOR SPECIFIED FRAGMENT HIT PROBABILITIES

DROP ANGLE	0.000 PROBABILITY	0.001 PROBABILITY	0.010 PROBABILITY
0°	1,280		
10°	1,320		
20°	2,130		
30°	2,770		
40°	3,610		
45°	4,270		
50°	5,340		
60°	7,040		

NOTE

Sight angles are based on 27,000 lb aircraft gross weight, 0 ft burst altitude, 0 ft target elevation, and 3 ft/sec ejection velocity. Released from Aero 7A EBR. Fragmentation data estimated from Mk 81, 82 and 83 general purpose low drag bombs.

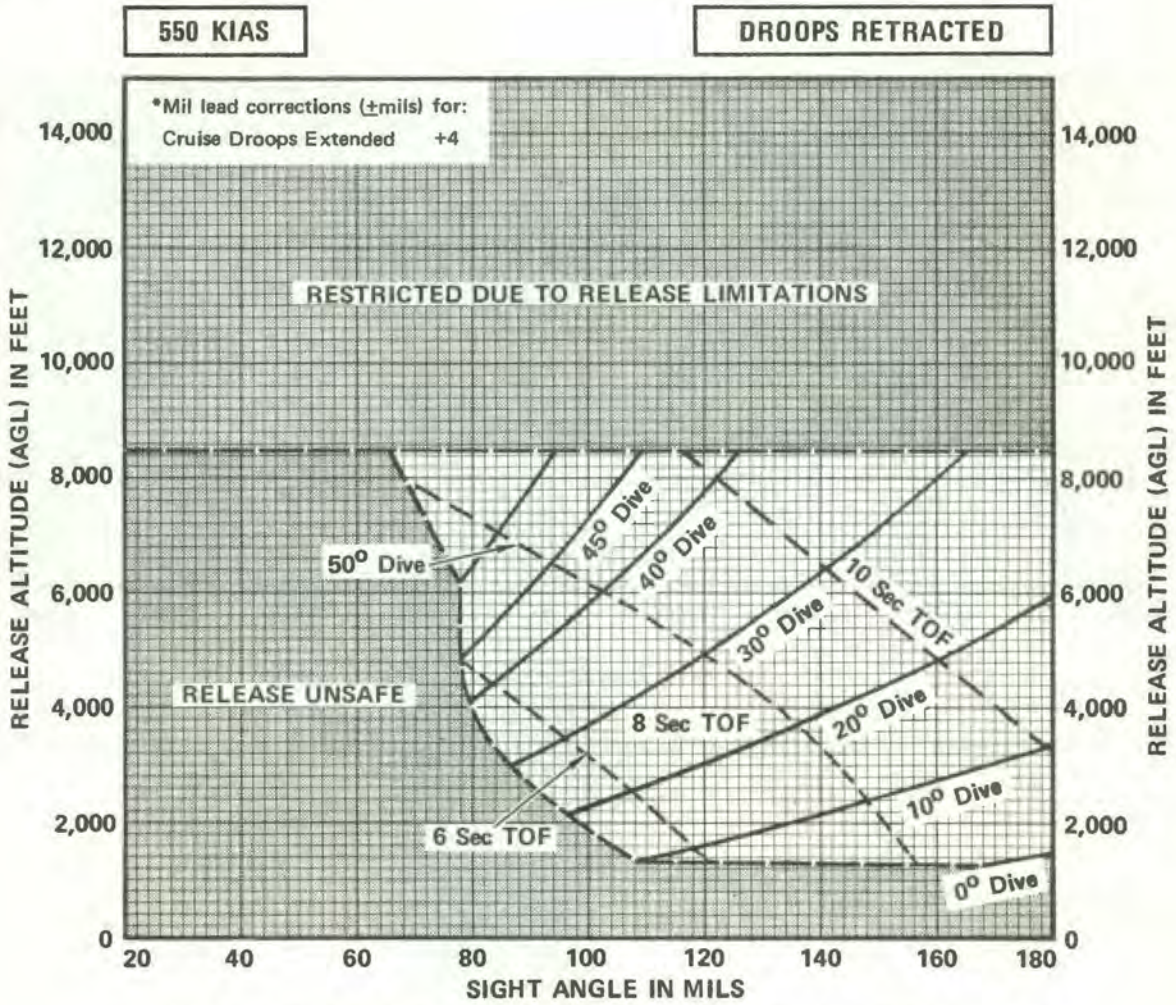
*For each 10° C increase (decrease) in release altitude temperature, increase (decrease) mil lead by 3 mils.

AZ-219(4)-03-69

Figure 2-69 (Sheet 4)

Mil Lead for Single Delivery

MK 84 CONICAL FIN



RELEASE ALTITUDES FOR SPECIFIED FRAGMENT HIT PROBABILITIES

DROP ANGLE	0.000 PROBABILITY	0.001 PROBABILITY	0.010 PROBABILITY
0°	1,180		
10°	1,400		
20°	2,230		
30°	2,980		
40°	4,080		
45°	4,840		
50°	6,000		
60°	7,920		

NOTE

Sight angles are based on 27,000 lb aircraft gross weight, 0 ft burst altitude, 0 ft target elevation, and 3 ft/sec ejection velocity. Released from Aero 7A EBR. Fragmentation data estimated from Mk 81, 82 and 83 general purpose low drag bombs.

*For each 10° C increase (decrease) in release altitude temperature, increase (decrease) mil lead by 3 mils.

AZ-219(5)-03-69

Figure 2-69 (Sheet 5)

Maximum Fragment Envelope

MK 84 GENERAL PURPOSE BOMB

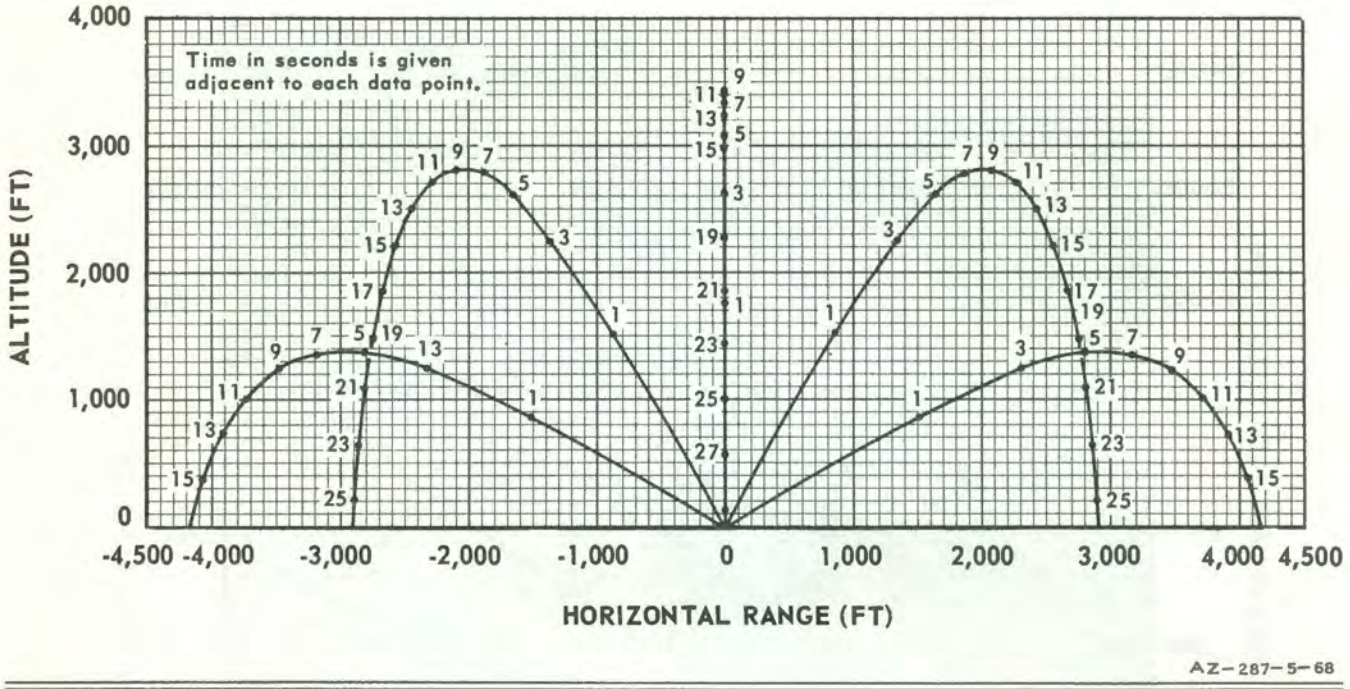


Figure 2–70

Tested Delivery Data

MK 84 CONICAL FIN

DIVE ANGLE	MIL LEAD		ENTRY			RELEASE			CORRECTION PER 10 KT OF DIRECT WIND – MILS		RELEASE ERROR SENSITIVITIES				
	EJECTED MILS	NON-EJECTED (MBR) – MILS	KIAS	ALTITUDE FT AGL	APPROX RPM %	KTAS	ALTITUDE FT AGL	ALTIMETER LAG – FT	Range	Cross	FT/KT KIAS	FT/100 FT ALTITUDE	FT/DEG DIVE ANGLE	FT/MIL RANGE	FT/MIL DEFLECTION
30°	128	NA	350	7,500	94	500	3,000	250	11	19	2	20	22	8	5
45°	126	NA	250	10,500	86	450	4,000	0	16	20	2	10	15	6	5

NOTES

1. Error sensitivities are applied as follows:

   Airspeed – Fast impacts long
   Slow impacts short

   Altitude – High impacts short
   Low impacts long

   Dive Angle – Steep impacts long
   Shallow impacts short

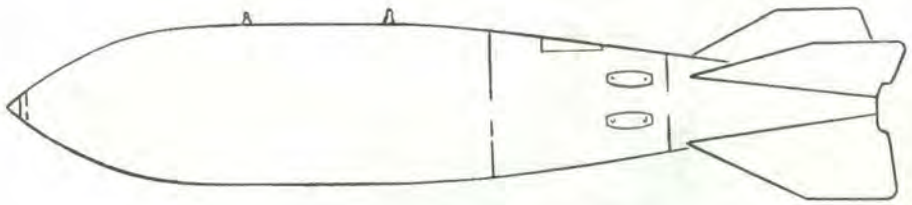
2. Mil lead computed for 28,000 lb aircraft with cruise droop extended.
   Correction – Add/subtract 1 mil for each 1,000 lb over/under 28,000 lb.

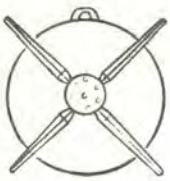
3. 45° dive profile flown with speed brakes OUT.

AZ-245-2-67

Figure 2-71

M117A1 Demolition Bomb





PHYSICAL CHARACTERISTICS

Weight Loaded – 823 pounds
Length – 87.4 inches
Diameter – 16 inches
Suspension lugs – 14 inches

DESCRIPTION

The M117A1 is a general purpose bomb normally used for demolition operations. The bomb has a cylindrical body with an ogival nose and a tapered aft section, which can be adapted for delivery either retarded or unretarded. The conical fin improves the aerodynamic performance of the bomb and permits greater accuracy. The bomb is designed primarily for electric fuzing, however, mechanical fuzes can be used provided adapter-boosters are installed in fuze cavities.

WING STATION LOADING CONFIGURATIONS		
WING LOADING	**EQUIPMENT-WEIGHT**	
AERO 7A-1 SUSPENSION One Bomb Each Wing	2 M117A1 2 Aero 7A-1 2 Pylons Total One Wing Only	1646 104 350 2100 1050
TER SUSPENSION Two Bombs Each Wing	4 M117A1 2 TER 2 Aero 7A-1 2 Pylons Total One Wing Only	3292 210 104 350 3956 1978
MER SUSPENSION Two Bombs Each Wing	4 M117A1 2 MER 2 Aero 7A-1 2 Pylons Total One Wing Only	3292 446 104 350 4192 2096

DROPPING PROCEDURE (Mechanical Fuzing)	DROPPING PROCEDURE (Electrical Fuzing)
1. Master Arm Sw – ON 2. Armament Sel Sw – Wing L or R 3. Mechanical Fuzing Sw – Nose or TAIL 4. Stores Release Sw – DEPRESS	1. Master Arm Sw – ON 2. Armament Sel Sw – Wing L or R 3. Option Sel Sw – As Desired 4. Safe-Stby-Ready Sw (AWW-1) – STBY for 30 sec then RDY 5. HVDC light – ON 6. Stores Release Sw – DEPRESS

NOTE

For simultaneous release from the Aero 7A-1 racks, the Triple-Multiple Rack Fire Mode switch must be set to the DUAL position and the Arm Sel Sw in the WING, L position.

To step the MER or TER stepping switch past an empty station, it is necessary to have the hooks at that station open or the stores release switch must be depressed and released once for each empty station between bombs. With the -501 or -521 TER or MER, the mechanical fuzing switch must also be placed in the NOSE position to obtain automatic stepping past the empty stations.

JETTISONING PROCEDURES

See JETTISONING this section.

REFERENCES

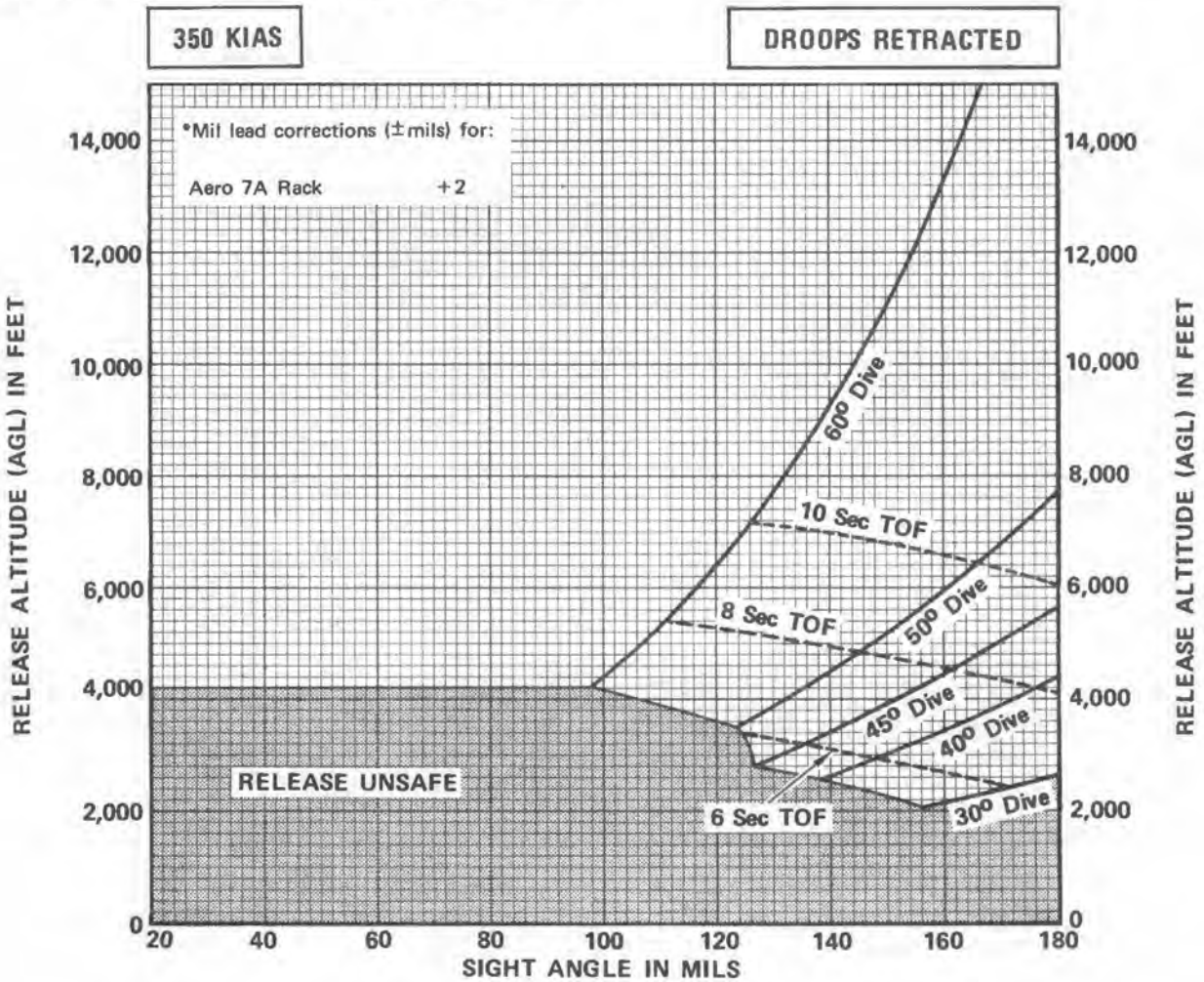
1. Restrictions – See Figure 2-2
2. Bomb Fuzing – NAVAIR 01-45HH-75 (OP 2216)
3. Preflight Inspection – NAVAIR 01-45HH-75
4. Bomb Loading Procedures – NAVAIR 01-45HH-75

AZ-264-03-69

Figure 2–72

Mil Lead for Single Delivery

M117A1 DEMOLITION BOMB CONICAL FIN



RELEASE ALTITUDES FOR SPECIFIED FRAGMENT HIT PROBABILITIES

DROP ANGLE	0.000 PROBABILITY	0.001 PROBABILITY	0.010 PROBABILITY
0°	2,240	1,360	1,090
10°	1,680	1,210	1,010
20°	2,200	1,690	1,440
30°	2,650	2,180	1,920
40°	3,160	2,680	2,360
45°	3,400	2,910	2,630
50°	3,610	3,310	3,310†
60°	4,150	4,150†	4,150†

NOTE

Sight angles are based on 27,000 lb aircraft gross weight, 0 ft burst altitude, 0 ft target elevation, and 4.2 ft/sec average ejection velocity. Released from MER or TER.

*For each 10° C increase (decrease) in temperature at release altitude, increase (decrease) the mil lead by 3 mils.

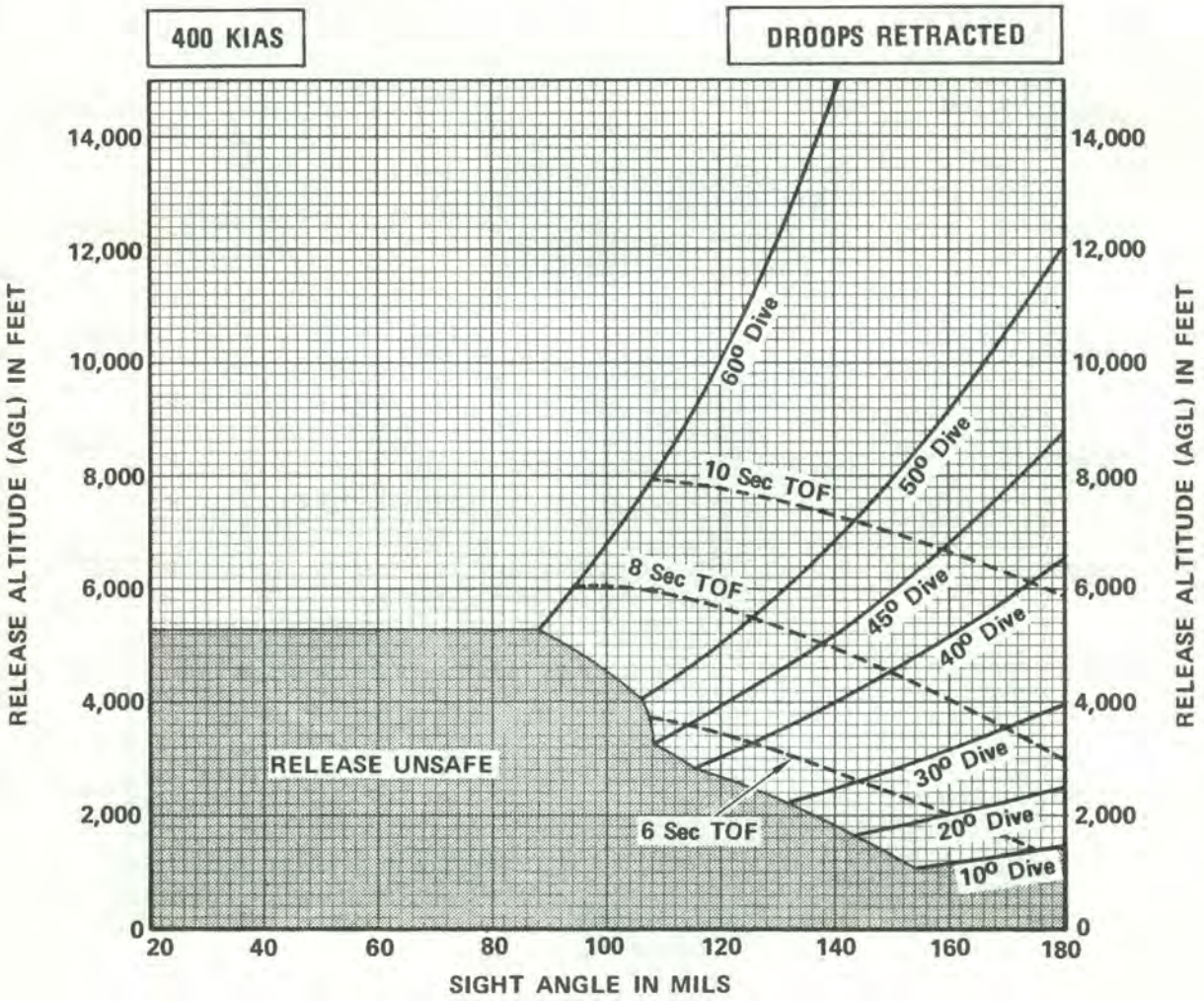
†Terrain avoidance is determining factor for this release altitude limitation.

AZ-276(1)-03-69

Figure 2-73 (Sheet 1)

Mil Lead for Single Delivery

M117A1 DEMOLITION BOMB CONICAL FIN



RELEASE ALTITUDES FOR SPECIFIED FRAGMENT HIT PROBABILITIES

DROP ANGLE	0.000 PROBABILITY	0.001 PROBABILITY	0.010 PROBABILITY
0°	1,960	1,330	980
10°	1,600	1,130	990
20°	2,220	1,750	1,540
30°	2,830	2,360	2,060
40°	3,370	2,910	2,690
45°	3,680	3,170	3,130
50°	3,930	3,930†	3,930†
60°	5,040	5,040†	5,040†

NOTE

Sight angles are based on 27,000 lb aircraft gross weight, 0 ft burst altitude, 0 ft target elevation, and 4.2 ft/sec average ejection velocity. Released from MER or TER.

*For each 10° C increase (decrease) in temperature at release altitude, increase (decrease) the mil lead by 3 mils.

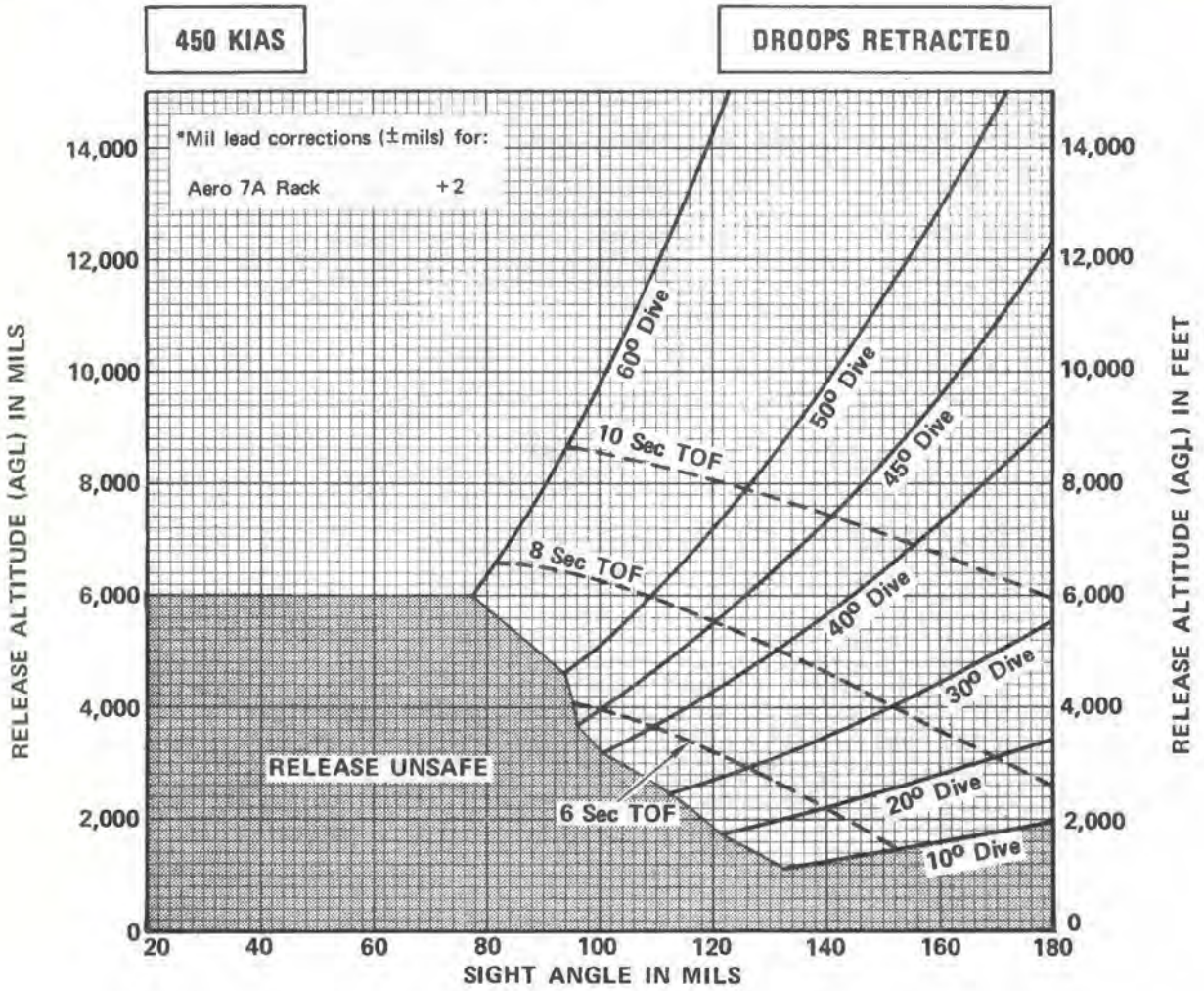
†Terrain avoidance is determining factor for this release altitude limitation.

AZ-276(2)-03-69

Figure 2-73 (Sheet 2)

Mil Lead for Single Delivery

M117A1 DEMOLITION BOMB CONICAL FIN



RELEASE ALTITUDES FOR SPECIFIED FRAGMENT HIT PROBABILITIES

DROP ANGLE	0.000 PROBABILITY	0.001 PROBABILITY	0.010 PROBABILITY
0°	1,760	1,230	890
10°	1,600	1,280	1,000
20°	2,300	1,920	1,600
30°	2,970	2,610	2,190
40°	3,630	3,240	3,130
45°	3,940	3,680	3,680†
50°	4,610	4,610†	4,610†
60°	6,030	6,030†	6,030†

NOTE

Sight angles are based on 27,000 lb aircraft gross weight, 0 ft burst altitude, 0 ft target elevation, and 4.2 ft/sec average ejection velocity. Released from MER or TER.

*For each 10° C increase (decrease) in temperature at release altitude, increase (decrease) the mil lead by 3 mils.

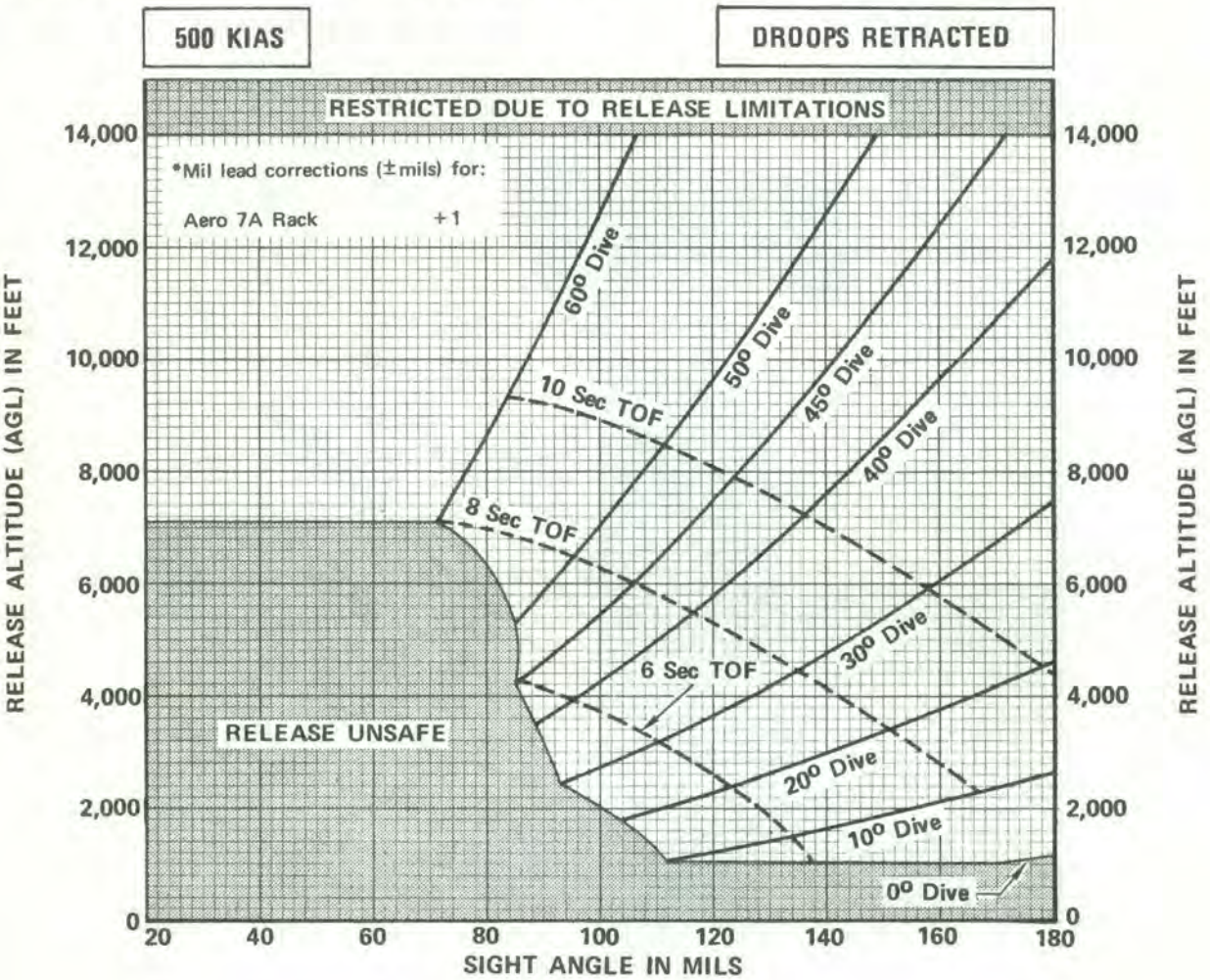
†Terrain avoidance is determining factor for this release altitude limitation.

AZ-276(3)-03-69

Figure 2-73 (Sheet 3)

Mil Lead for Single Delivery

M117A1 DEMOLITION BOMB CONICAL FIN



RELEASE ALTITUDES FOR SPECIFIED FRAGMENT HIT PROBABILITIES

DROP ANGLE	0.000 PROBABILITY	0.001 PROBABILITY	0.010 PROBABILITY
0°	1,560	1,230	840
10°	1,600	1,290	1,050
20°	2,330	2,050	1,690
30°	3,140	2,770	2,320
40°	3,900	3,610	3,610†
45°	4,270	4,270†	4,270†
50°	5,340	5,340†	5,340†
60°	7,040	7,040†	7,040†

NOTE

Sight angles are based on 27,000 lb aircraft gross weight, 0 ft burst altitude, 0 ft target elevation, and 4.2 ft/sec average ejection velocity. Released from MER or TER.

*For each 10° C increase (decrease) in temperature at release altitude, increase (decrease) the mil lead by 3 mils.

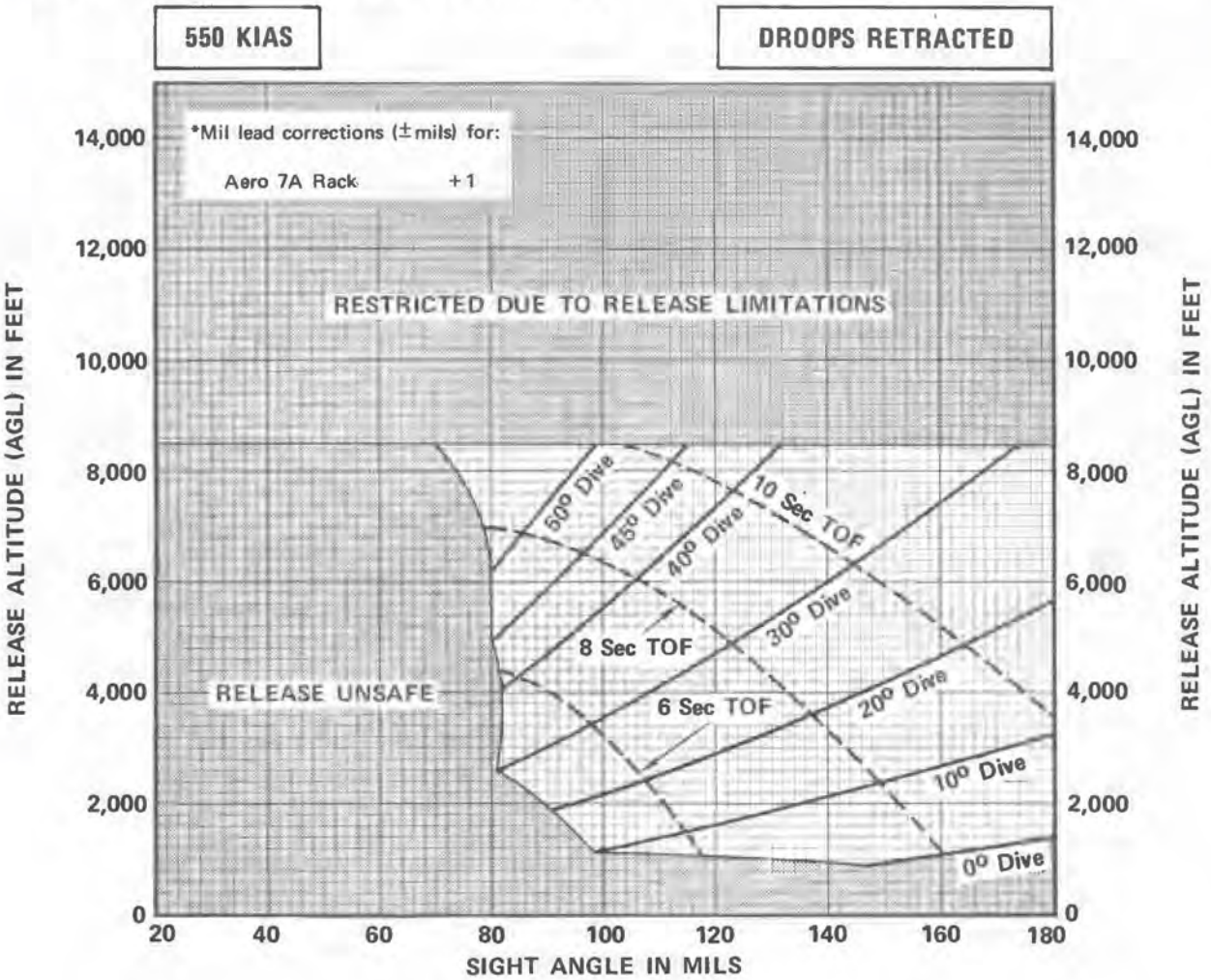
†Terrain avoidance is determining factor for this release altitude limitation.

AZ-276(4)-03-69

Figure 2-73 (Sheet 4)

Mil Lead for Single Delivery

M117A1 DEMOLITION BOMB CONICAL FIN



RELEASE ALTITUDES FOR SPECIFIED FRAGMENT HIT PROBABILITIES

DROP ANGLE	0.000 PROBABILITY	0.001 PROBABILITY	0.010 PROBABILITY
0°	1,360	1,060	760
10°	1,600	1,300	1,080
20°	2,430	2,130	1,780
30°	3,290	2,940	2,570
40°	4,110	4,080	4,080†
45°	4,840	4,840†	4,840†
50°	6,000	6,000†	6,000†
60°	7,920	7,920†	7,920†

NOTE

Sight angles are based on 27,000 lb aircraft gross weight, 0 ft burst altitude, 0 ft targer elevation, and 4.2 ft/sec average ejection velocity. Released from MER or TER.

*For each 10° C increase (decrease) in temperature at release altitude, increase (decrease) the mil lead by 3 mils.

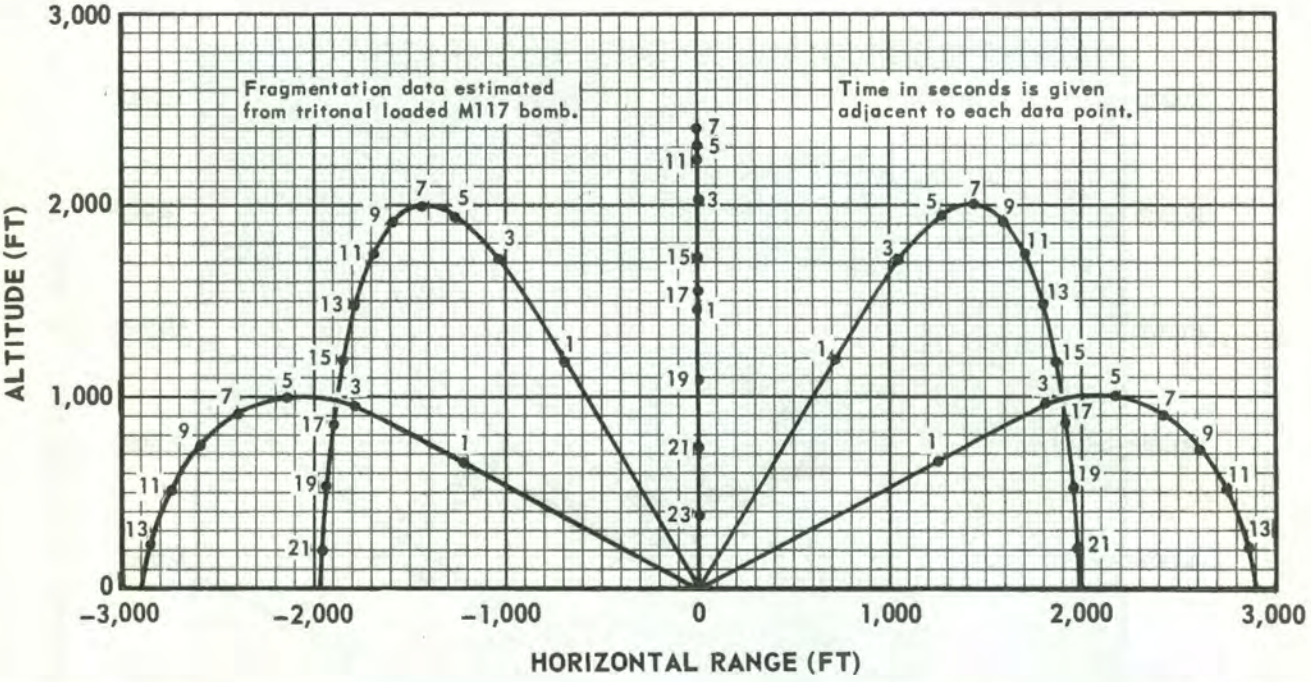
†Terrain avoidance is determining factor for this release altitude limitation.

AZ-276(5)-03-69

Figure 2-73 (Sheet 5)

Maximum Fragment Envelope

M117A1 DEMOLITION BOMB

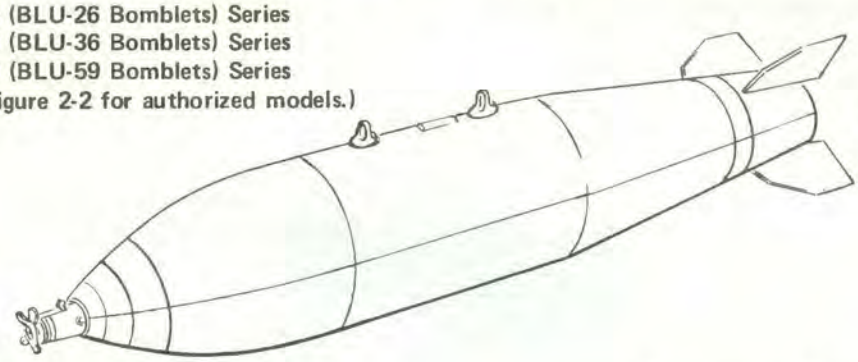


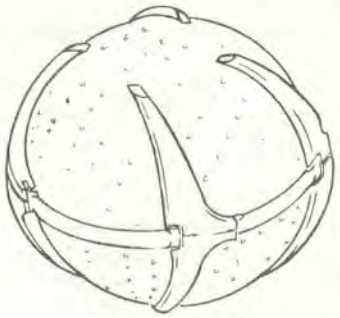
AZ−293−5−68

Figure 2–74

SUU-30/B, -30A/B, -30C/B Dispensers

CBU-24 (BLU-26 Bomblets) Series
CBU-29 (BLU-36 Bomblets) Series
CBU-49 (BLU-59 Bomblets) Series
(See figure 2-2 for authorized models.)





BLU-26, BLU-36 or BLU-59 Bomblets

PHYSICAL CHARACTERISTICS

Weight (Loaded – 830 pounds
Length – 92.6 inches
Diameter – 16.0 inches
Suspension lugs – 14 inches apart

DESCRIPTION

The SUU-30/B, -30A/B and -30C/B dispensers are used to make up the cluster bomb units (CBU) shown above. Each CBU consists of a SUU-30 dispenser, fuzed bomblets, and a mechanical time nose fuze.

The dispensers are divided in half longitudinally. The two halves are locked together by a nose locking cap and a ring and plate assembly at the aft end. The SUU-30A/B and the SUU-30C/B dispensers are basically a SUU-30/B which has been modified to eliminate tension members and incorporates a modified fin assembly that provides improved aerodynamics. Canted aluminum alloy fins impart spin to the dispenser when released.

The BLU-26, -36 and -59 bomblets are identical except for the type of fuze used. BLU-26 bomblets detonate instantaneously on impact. BLU-36 bomblets provide random delays which range from 0 to 120 minutes with about 50 percent detonating within 10 minutes after impact. BLU-59 bomblets provide random delays which range from 0 to 30 minutes with about 50 percent detonating within 8 minutes after impact. There is no external feature that indicates the bomblet is armed.

WING STATION LOADING CONFIGURATIONS

WING LOADING	EQUIPMENT-WEIGHT	
AERO 7A-1 SUSPENSION One Bomb Each Wing	2 CBU-24, -29, -49 2 Aero 7A-1 2 Pylons Total One Wing Only	1,660 104 350 2,114 1,057
TER SUSPENSION Two Bombs Each Wing	4 CBU-24, -29, -49 2 Aero 7A-1 2 Pylons 2 TER Total One Wing Only	3,320 104 350 210 3,984 1,992
MER SUSPENSION Two Bombs Each Wing	4 CBU-24, -29, -49 2 Aero 7A-1 2 Pylons 2 MER Total One Wing Only	3,320 104 350 446 4,220 2,110

DROPPING PROCEDURES

1. **Master Arm Sw – ON**
2. **Armament Sel Sw – Wing L or R**
3. **Mechanical Fuzing Sw – NOSE and TAIL**
4. **Stores Release Sw – DEPRESS**

NOTE

For simultaneous release from Aero 7A-1 racks from both pylons, the Triple-Multiple Rack Fire Mode switch in each pylon must be set to the DUAL position and the Arm Sel Sw to the WING L position.

To step the MER or TER stepping switch past an empty station, it is necessary to have the hooks at that station open or the stores release switch must be depressed and released once for each empty station between bombs. With the -505 or -521 TER or MER, the mechanical fuzing switch must also be placed in the NOSE position to obtain automatic stepping past the empty station.

JETTISONING PROCEDURES

See JETTISONING this section.

REFERENCES

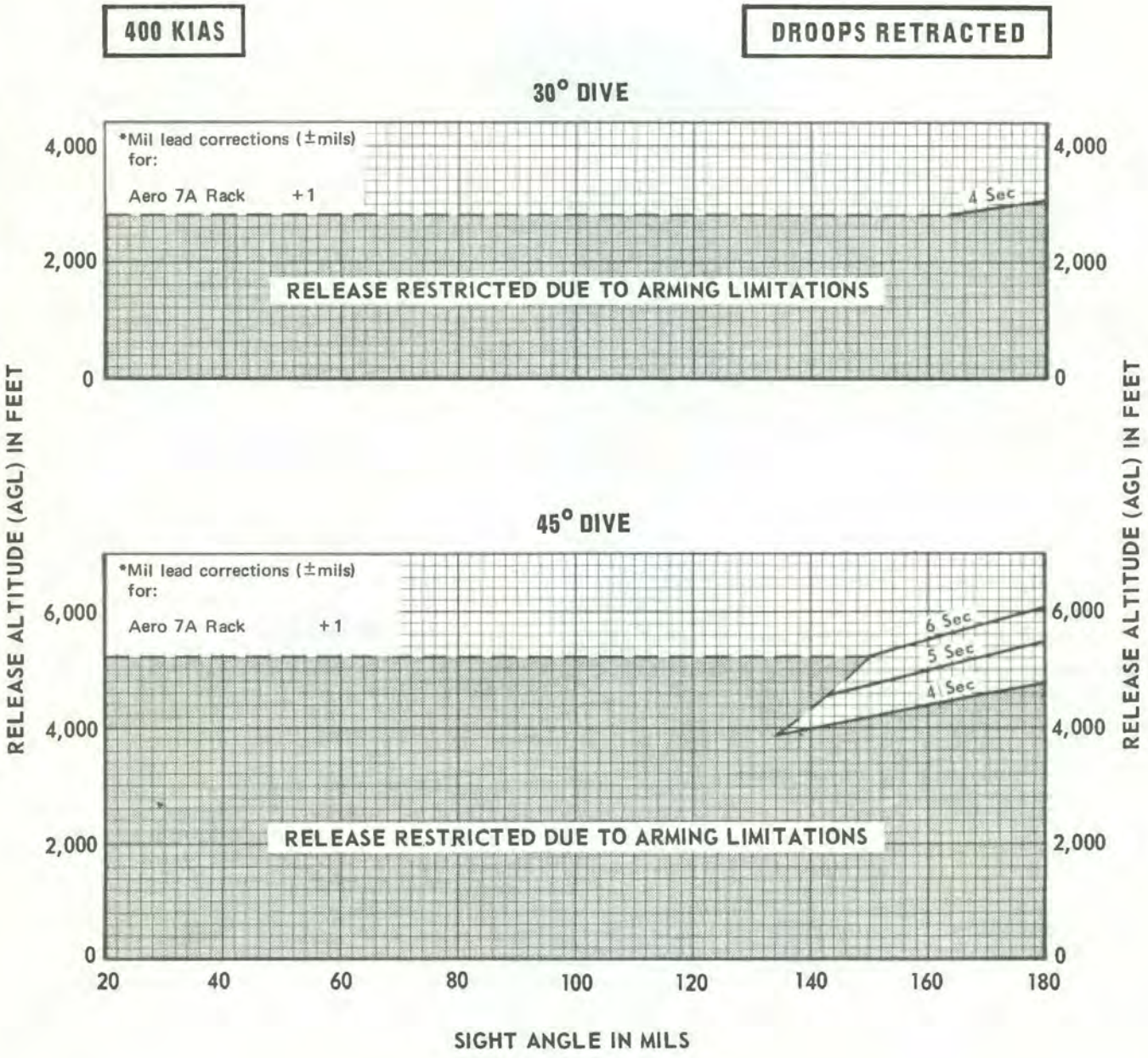
1. Restrictions – See Figure 2-2
2. Bomb Fuzing – NAVAIR 11-5A-17 (OP 2216)
3. Preflight Inspections – NAVAIR 01-45HH-75
4. Bomb Arming – NAVAIR 01-45HH-75
5. Dispensers – NAVAIR 11-5A-1

AZ-267-03-70

Figure 2–75 (U)

Mil Lead for Single Delivery

SUU-30 DISPENSER, CBU-24, -29, -49 SERIES



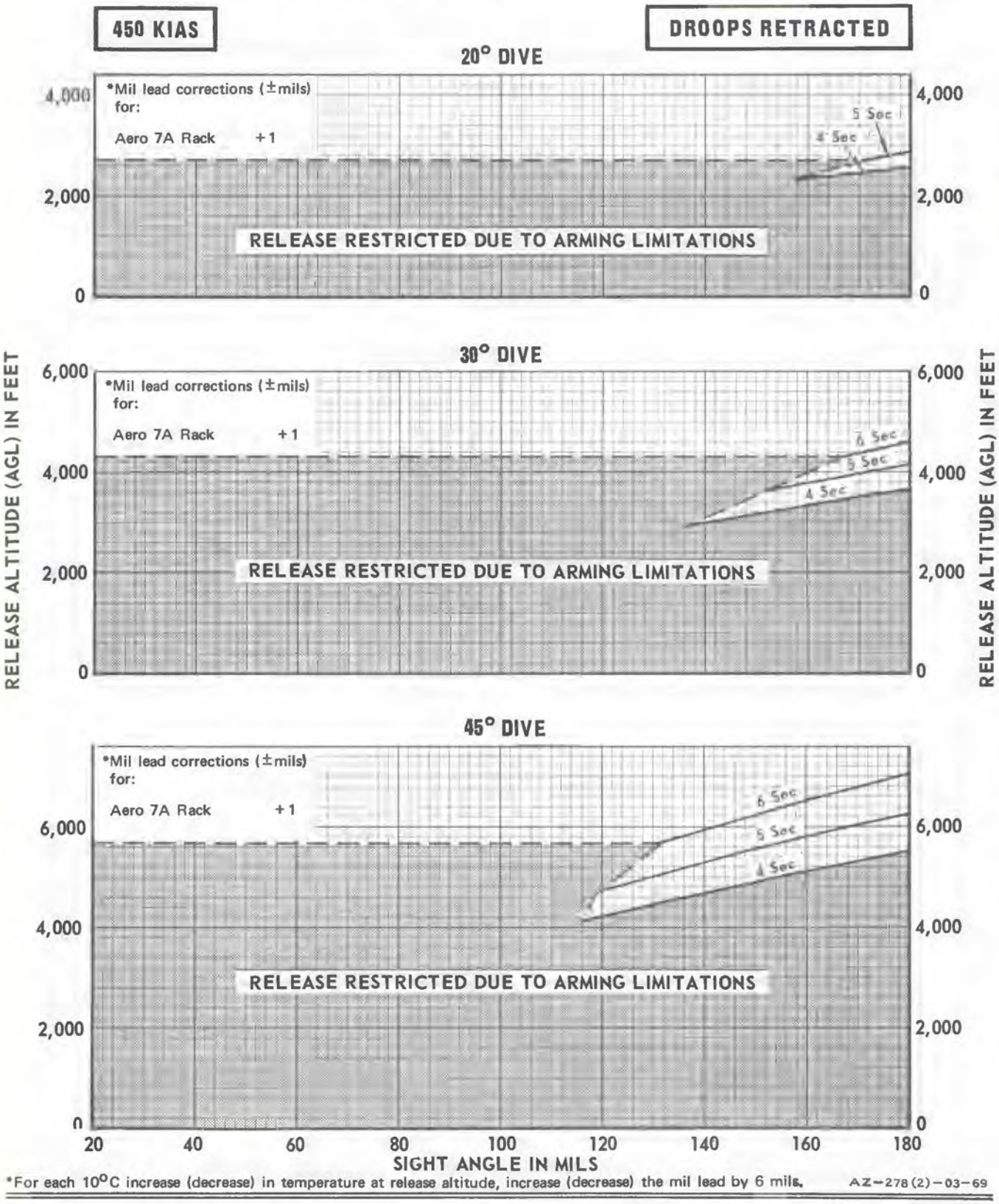
*For each 10°C increase (decrease) in temperature at release altitude, increase (decrease) the mil lead by 6 mils.

AZ-278(1)-03-69

Figure 2–76 (Sheet 1)

Mil Lead for Single Delivery

SUU-30 DISPENSER, CBU-24, -29, -49 SERIES



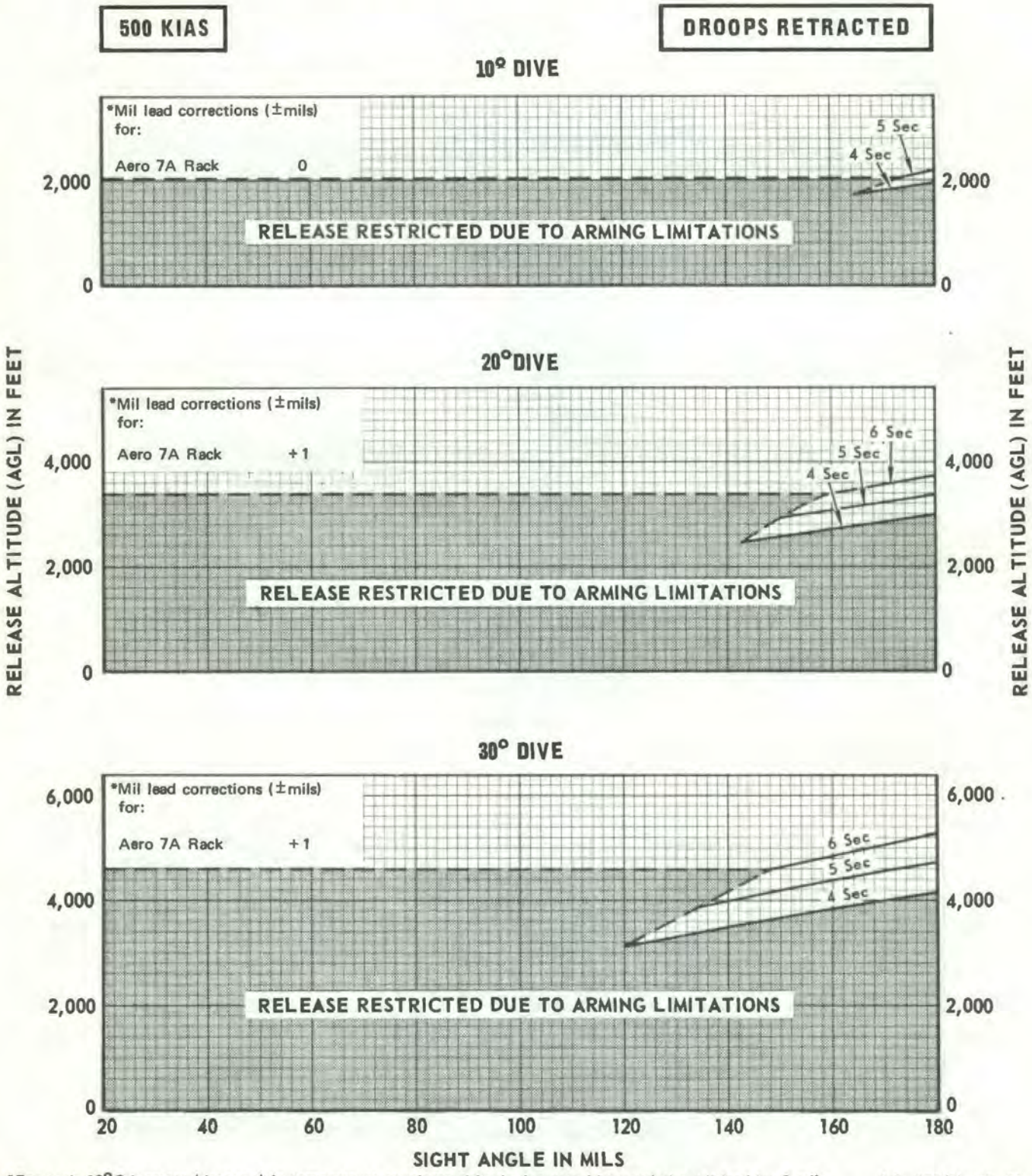
*For each 10°C increase (decrease) in temperature at release altitude, increase (decrease) the mil lead by 6 mils.

AZ-278(2)-03-69

Figure 2-76 (Sheet 2)

Mil Lead for Single Delivery

SUU-30 DISPENSER, CBU-24, -29, -49 SERIES



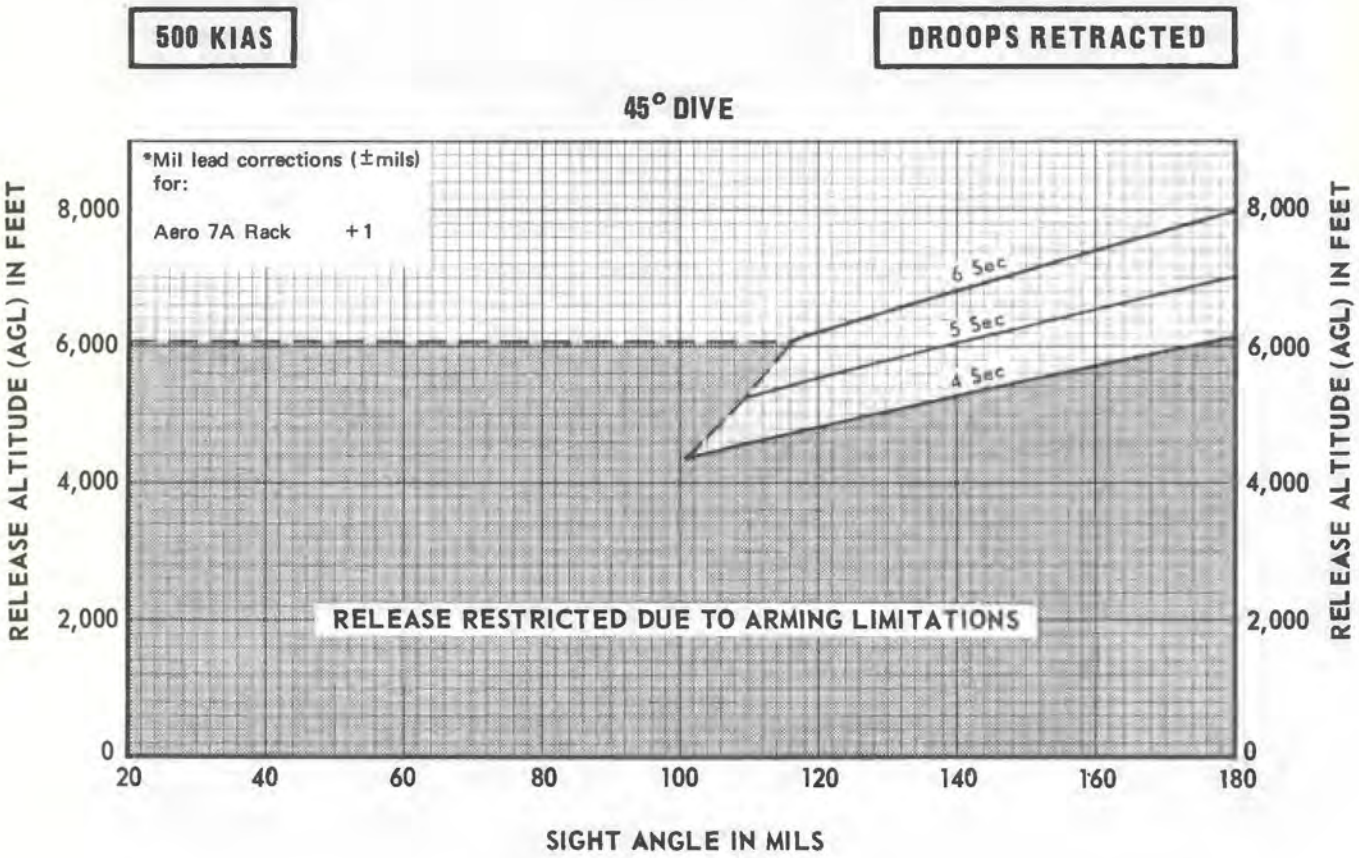
*For each 10°C increase (decrease) in temperature at release altitude, increase (decrease) the mil lead by 6 mils.

AZ-278(3)-03-69

Figure 2-76 (Sheet 3)

Mil Lead for Single Delivery

SUU-30 DISPENSER, CBU-24, -29, -49 SERIES



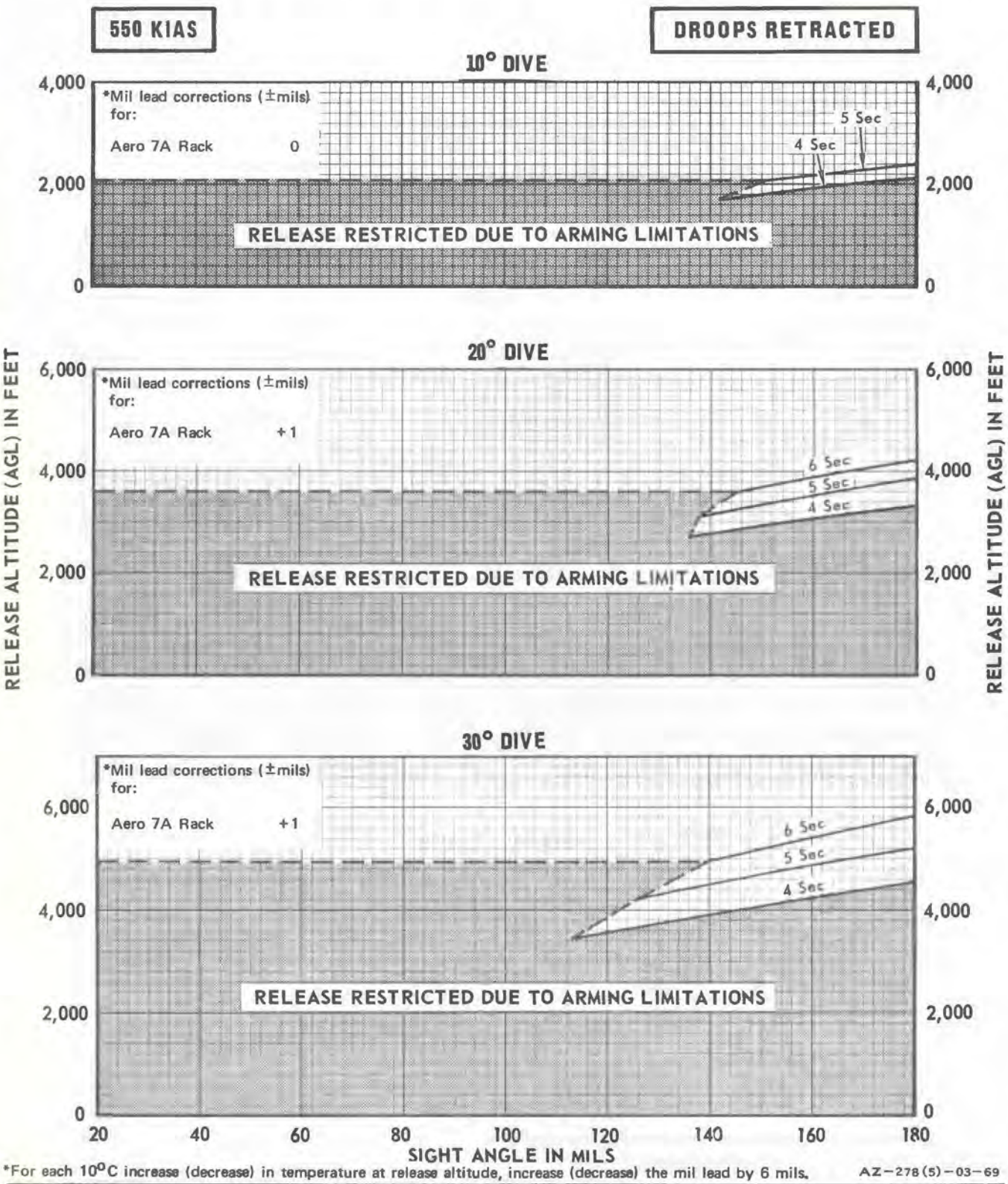
*For each 10°C increase (decrease) in temperature at release altitude, increase (decrease) the mil lead by 6 mils.

AZ-278(4)-03-69

Figure 2-76 (Sheet 4)

Mil Lead for Single Delivery

SUU-30 DISPENSER, CBU-24, -29, -49 SERIES



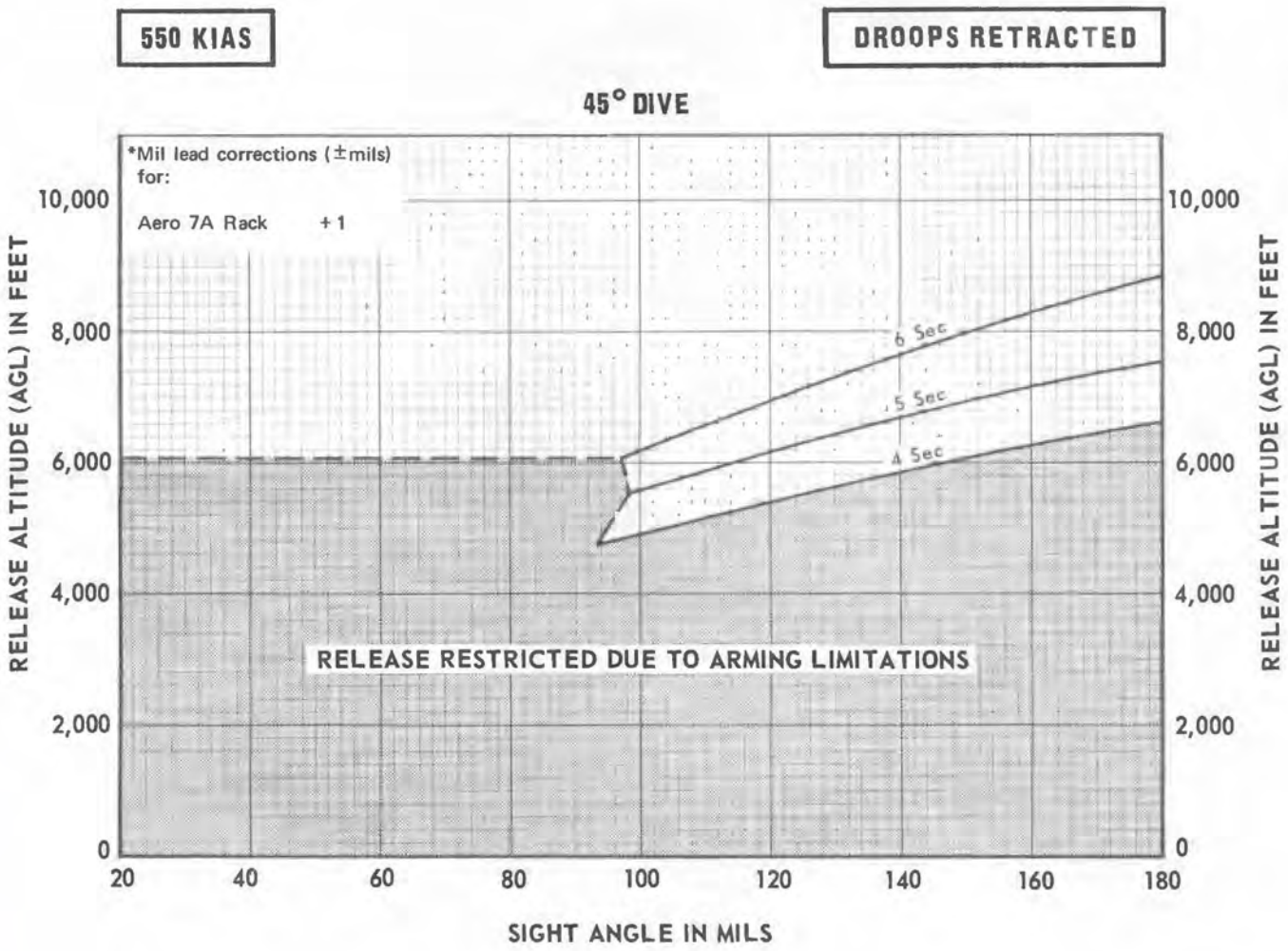
*For each 10°C increase (decrease) in temperature at release altitude, increase (decrease) the mil lead by 6 mils.

AZ-278(5)-03-69

Figure 2-76 (Sheet 5)

Mil Lead for Single Delivery

SUU-30 DISPENSER, CBU-24, -29, -49 SERIES



NOTE

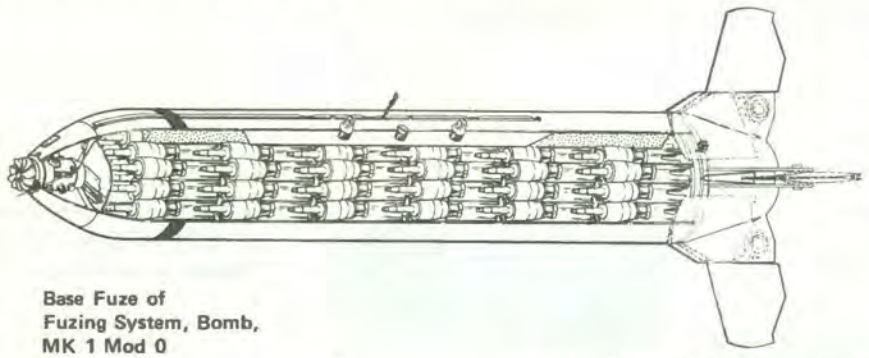
Sight angles are based on 27,000-lb aircraft gross weight, 0-ft burst altitude, 0-ft target elevation, and 4.8 ft/sec average ejection velocity.

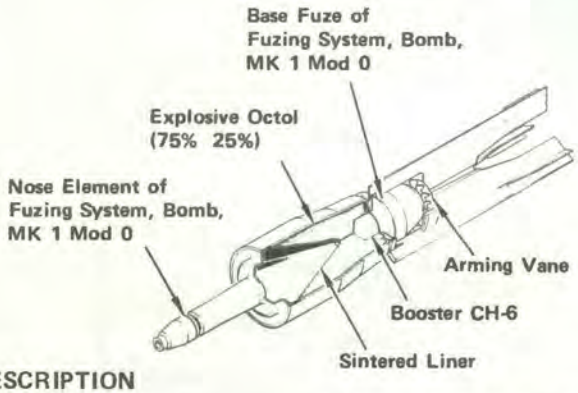
*For each 10°C increase (decrease) in temperature at release altitude, increase (decrease) the mil lead by 6 mils.

AZ-278(6)-03-69

Figure 2-76 (Sheet 6)

MK 20 Mod 2 (Rockeye II) Bomb





PHYSICAL CHARACTERISTICS

ROCKEYE II	
Weight of loaded dispenser	−460.0 Pounds
Length (with fuze)	−92.0 Inches
Diameter	−13.2 Inches

MK 118 MOD 0 BOMBLET	
Weight	−1.32 Pounds
Length	−13.50 Inches
Diameter	−2.10 Inches
Weight of explosive	−0.39 Pounds

DESCRIPTION

The ROCKEYE II is an unguided cluster bomb designed for tactical use against tanks and armored vehicles. The major components of the ROCKEYE II are the Mk 7 Mod 2 dispenser, the MK 339 Mod 0 dispenser fuze, and 247 MK 118 Mod 0 antitank/antipersonnel bomblets.

The MK 118 bomblet utilizes the MK 1 Mod 0 Fuzing System. This system contains a small tail mounted arming vane which arms the bomblet in about 1.5 seconds after release from the dispenser. An airspeed of 200 KIAS or greater is required for reliable arming of the bomblet. A nose element in the fuze detonates the bomblet instantaneously and with a shaped charge effect on impact with hard targets (steel, concrete). The tail fuze detonates the bomblet after a very short delay on impact with softer targets. A discriminating feature of the fuze permits penetration of light material (vegetation, camouflage nets, light plywood) without detonation.

A small observation window in the side of the tail fuze shows RED if armed, GREEN if safe.

WING STATION LOADING CONFIGURATIONS

WING LOADING	EQUIPMENT-WEIGHT	
AERO 7A-1 SUSPENSION One Bomb Each Wing	2 Mk 20 Mod 2	920
	2 Aero 7A-1	104
	2 Pylons	350
	Total	1,374
	One Wing Only	687
TER SUSPENSION Two Bombs Each Wing	4 Mk 20 Mod 2	1,840
	2 TER	210
	2 Aero 7A-1	104
	2 Pylons	350
	Total	2,504
	One Wing Only	1,252
MER SUSPENSION Four Bombs Each Wing	8 Mk 20 Mod 2	3,680
	2 MER	446
	2 Aero 7A-1	104
	2 Pylons	350
	Total	4,580
	One Wing Only	2,290

DROPPING PROCEDURE

(Mechanical Fuzing)

1. **Master Arm Sw – ON**
2. **Armament Sel Sw – Wing L or R**
3. **Mechanical Fuzing Sw – NOSE or TAIL**
4. **Stores Release Sw – DEPRESS**

NOTE

For simultaneous releases from the Aero 7A-1 racks, the Triple–Multiple Rack Fire Mode switch must be set to the DUAL position and the Arm Sel Sw in the WING, L position.

To step the MER or TER stepping switch past an empty station, it is necessary to have the hooks at that station open or the stores release switch must be depressed and released once for each empty station between bombs. With the -505 or -521 TER or MER, the mechanical fuzing switch must also be placed in the NOSE position to obtain automatic stepping past empty stations.

JETTISONING PROCEDURES

See JETTISONING, this section.

REFERENCES

1. Restrictions – See Figure 2-2
2. Bomb Fuzing – NAVAIR 11-5A-17 (OP 2216)
3. Preflight Inspection – NAVAIR 01-45HH-75
4. Bomb Loading Procedures – NAVAIR 01-45HH-75

AZ−341−03−70

Figure 2–77 (C)(Gp-4)

Mil Lead for Single Delivery

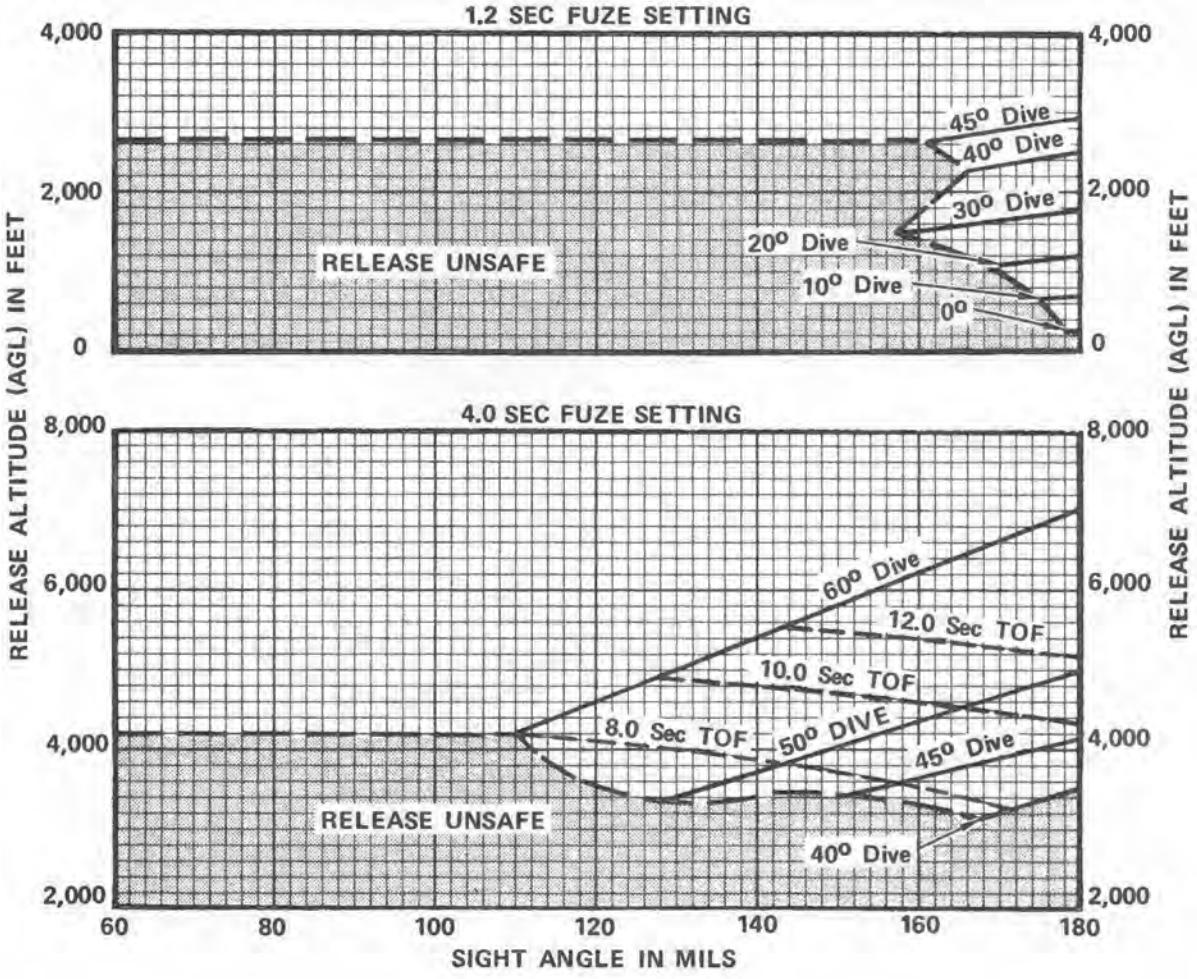
MK 20 MOD 2 (ROCKEYE)

MIL LEAD CORRECTIONS (± MILS) FOR:

AERO 7A	+2								
RELEASE ALTITUDE TEMP - VARIATION	DIVE ANGLE	0°	10°	20°	30°	40°	45°	50°	60°
±10°C		±2	±4	±4	±5	±5	±5	±5	±5 MILS
±30°C		±7	±11	±12	±14	±16	±16	±14	±14

350 KIAS

DROOPS RETRACTED



NOTE

Sight angles are based on 27,000 lb aircraft gross weight, 0 ft burst altitude, 0 ft target elevation, and 6.0 ft/sec average ejection velocity of MER and TER. For increase (decrease) in temperature, increase (decrease) the mil lead; linear interpolation shall be used for nonstandard temperatures other than those given.

AZ-318(1)-03-69

Figure 2-78 (Sheet 1)

Mil Lead for Single Delivery

MK 20 MOD 2 (ROCKEYE)

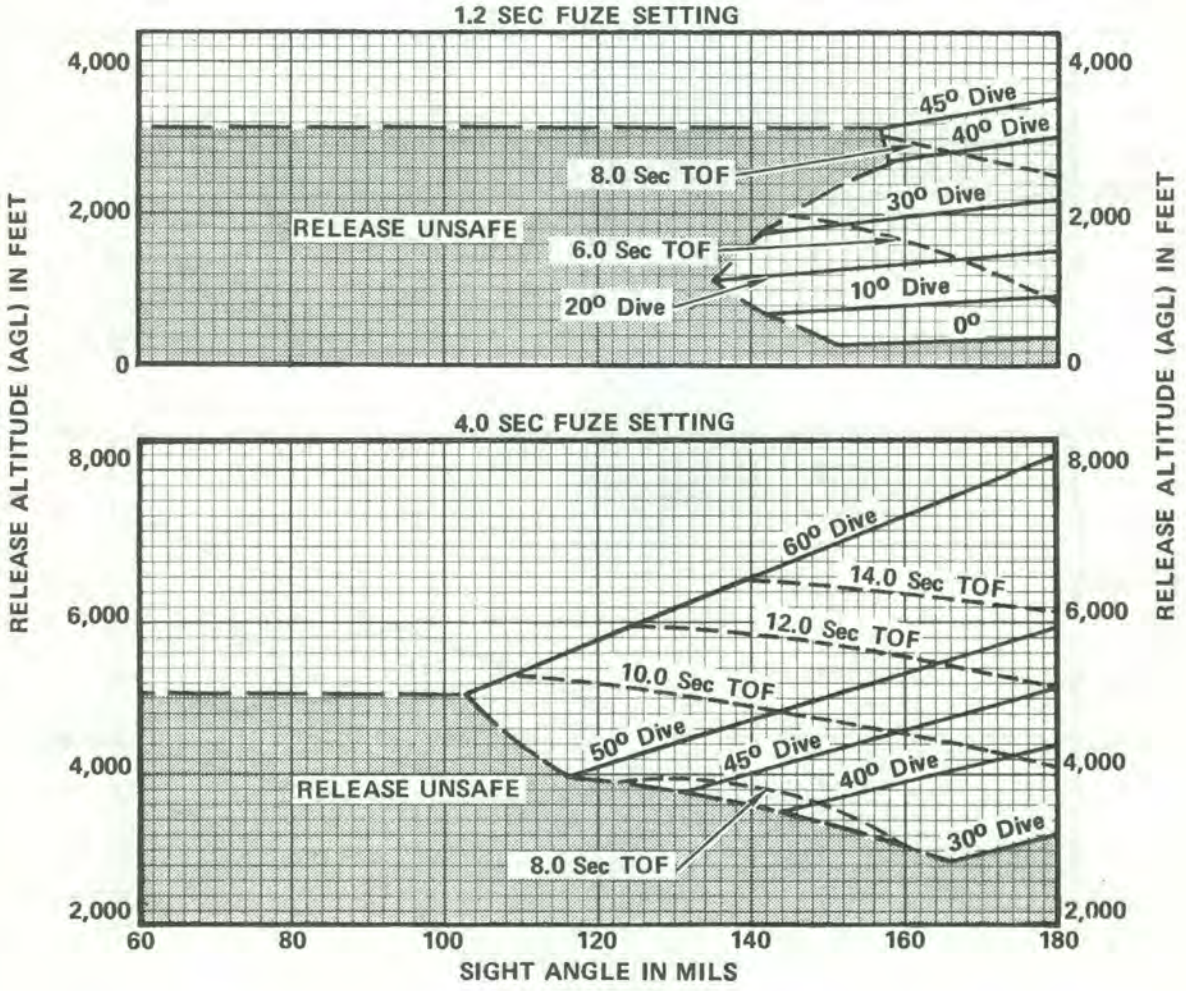
MIL LEAD CORRECTIONS (± MILS) FOR:

AERO 7D	+2								
RELEASE ALTITUDE TEMP-VARIATION	DIVE ANGLE	0°	10°	20°	30°	40°	45°	50°	60°
±10°C		±2	±4	±4	±5	±5	±5	±5	±5
±30°C		±7	±11	±12	±14	±16	±16	±14	±14

MILS

400 KIAS

DROOPS RETRACTED



NOTE

Sight angles are based on 27,000 lb aircraft gross weight, 0 ft burst altitude, 0 ft target elevation, and 6.0 ft/sec average ejection velocity of MER and TER. For increase (decrease) in temperature increase (decrease) the mil lead; linear interpolation shall be used for nonstandard temperatures other than those given.

AZ-318(2)-03-69

Figure 2-78 (Sheet 2)

Mil Lead for Single Delivery

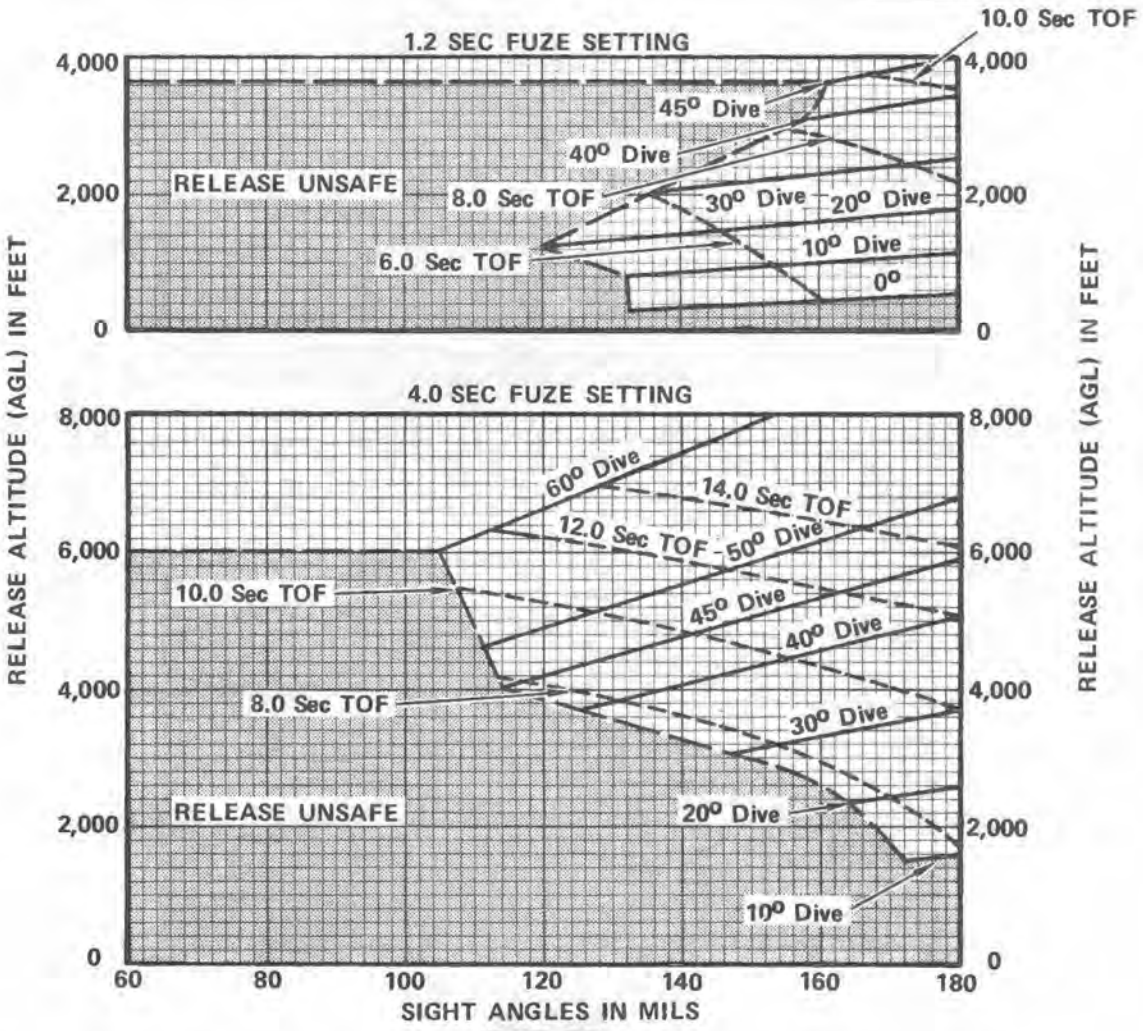
MK 20 MOD 2 (ROCKEYE)

MIL LEAD CORRECTIONS (± MILS) FOR:

AERO 7A	1.2 FUZE, +1:			4.0 FUZE, +2					
RELEASE ALTITUDE TEMP - VARIATION	DIVE ANGLE	0°	10°	20°	30°	40°	45°	50°	60°
±10°C		±2	±4	±4	±5	±5	±5	±5	±5 MILS
±30°C		±7	±11	±12	±14	±16	±16	±14	±14

450 KIAS

DROOPS RETRACTED



NOTE

Sight angles are based on 27,000 lb aircraft gross weight, 0 ft burst altitude, 0 ft target elevation, and 6.0 ft/sec average ejection velocity of MER and TER. For increase (decrease) in temperature, increase (decrease) the mil lead; linear interpolation shall be used for nonstandard temperatures other than those given.

AZ-318(3)-03-69

Figure 2-78 (Sheet 3)

Mil Lead for Single Delivery

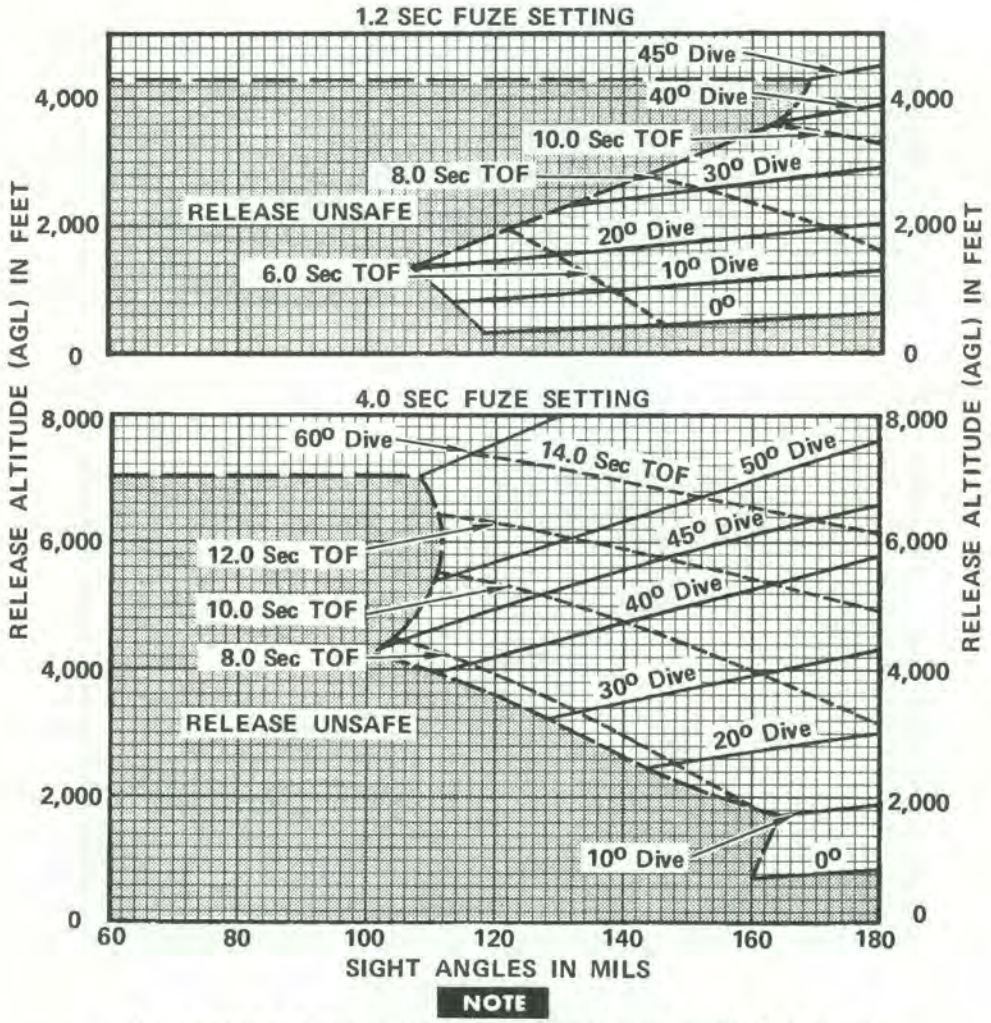
MK 20 MOD 2 (ROCKEYE)

MIL LEAD CORRECTIONS (± MILS) FOR:

AERO 7A	+1								
RELEASE ALTITUDE TEMP-VARIATION	DIVE ANGLE	0°	10°	20°	30°	40°	45°	50°	60°
±10°C		±2	±4	±4	±5	±5	±5	±5	±5 MILS
±30°C		±7	±11	±12	±14	±16	±16	±14	±14

500 KIAS

DROOPS RETRACTED



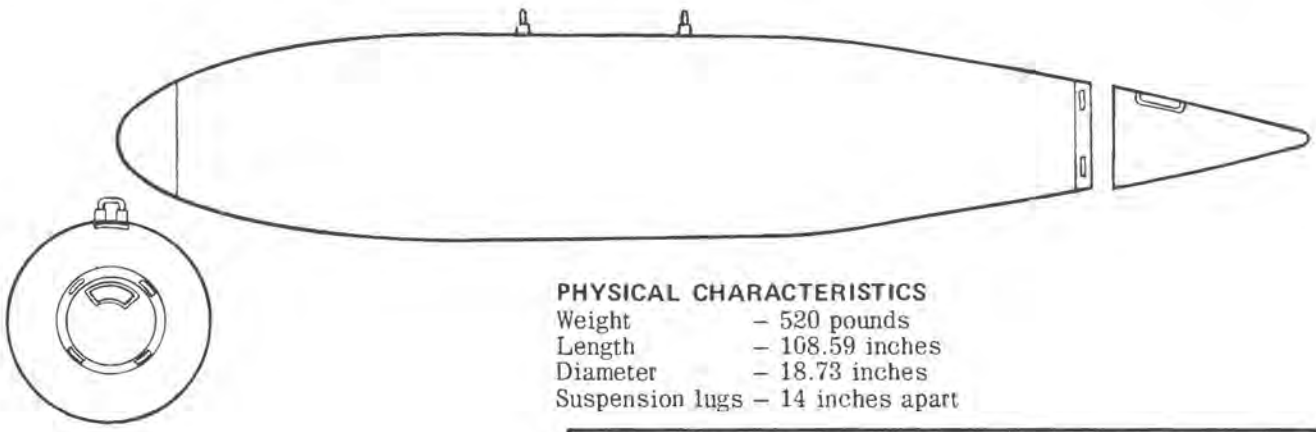
NOTE

Sight angles are based on 27,000 lb aircraft gross weight, 0 ft burst altitude, 0 ft target elevation, and 6.0 ft/sec average ejection velocity of MER and TER. For increase (decrease) in temperature, increase (decrease) the mil lead; linear interpolation shall be used for non-standard temperatures other than those given.

AZ-318(4)-03-69

Figure 2-78 (Sheet 4)

MK 77 Mod 2 and 4 Fire Bomb



PHYSICAL CHARACTERISTICS

Weight – 520 pounds
Length – 108.59 inches
Diameter – 18.73 inches
Suspension lugs – 14 inches apart

DESCRIPTION

The Mk 77 Mod 2 or Mod 4 is a 500-pound fire bomb. The bomb is constructed of thin aluminum and has detachable nose and tail cones. These cones are ejected by springs when the cone release wires are withdrawn at weapon release. The bomb container capacity is 75 gallons of gasoline and napalm mix. Once filled the bomb must be expended or jettisoned.

WING STATION LOADING CONFIGURATIONS

WING LOADING	EQUIPMENT-WEIGHT
AERO 7A-1 SUSPENSION One Bomb Each Wing 	2 MK 77 1040 2 Aero 7A-1 104 2 Pylons 350 Total 1494 One Wing Only 747
TER SUSPENSION One Bomb Each Wing 	2 MK 77 1040 2 Aero 7A-1 104 2 Pylons 350 2 TER 210 Total 1704 One Wing Only 852
MER SUSPENSION Two Bombs Each Wing 	4 MK 77 2080 2 Aero 7A-1 104 2 Pylons 350 2 MER 446 Total 2980 One Wing Only 1490

DROPPING PROCEDURES

1. Master Arm Sw – ON
2. Armament Sel Sw – Wing L or R
3. Mechanical Fuzing Sw – NOSE and TAIL
4. Stores Release Sw – DEPRESS

NOTE

For simultaneous releases from Aero 7A-1 racks, the Triple-Multiple Rack Fire Mode switch in each pylon must be set to the DUAL position and the Arm Sel Sw to the WING L position.

To step the MER stepping switch past an empty station, it is necessary to have the hooks at that station open or the stores release switch must be depressed and released once for each empty station between bombs. With the -501 or -521 MER the mechanical fuzing switch must also be placed in the NOSE position to obtain automatic stepping past empty stations.

JETTISONING PROCEDURES

See JETTISONING this section.

REFERENCES

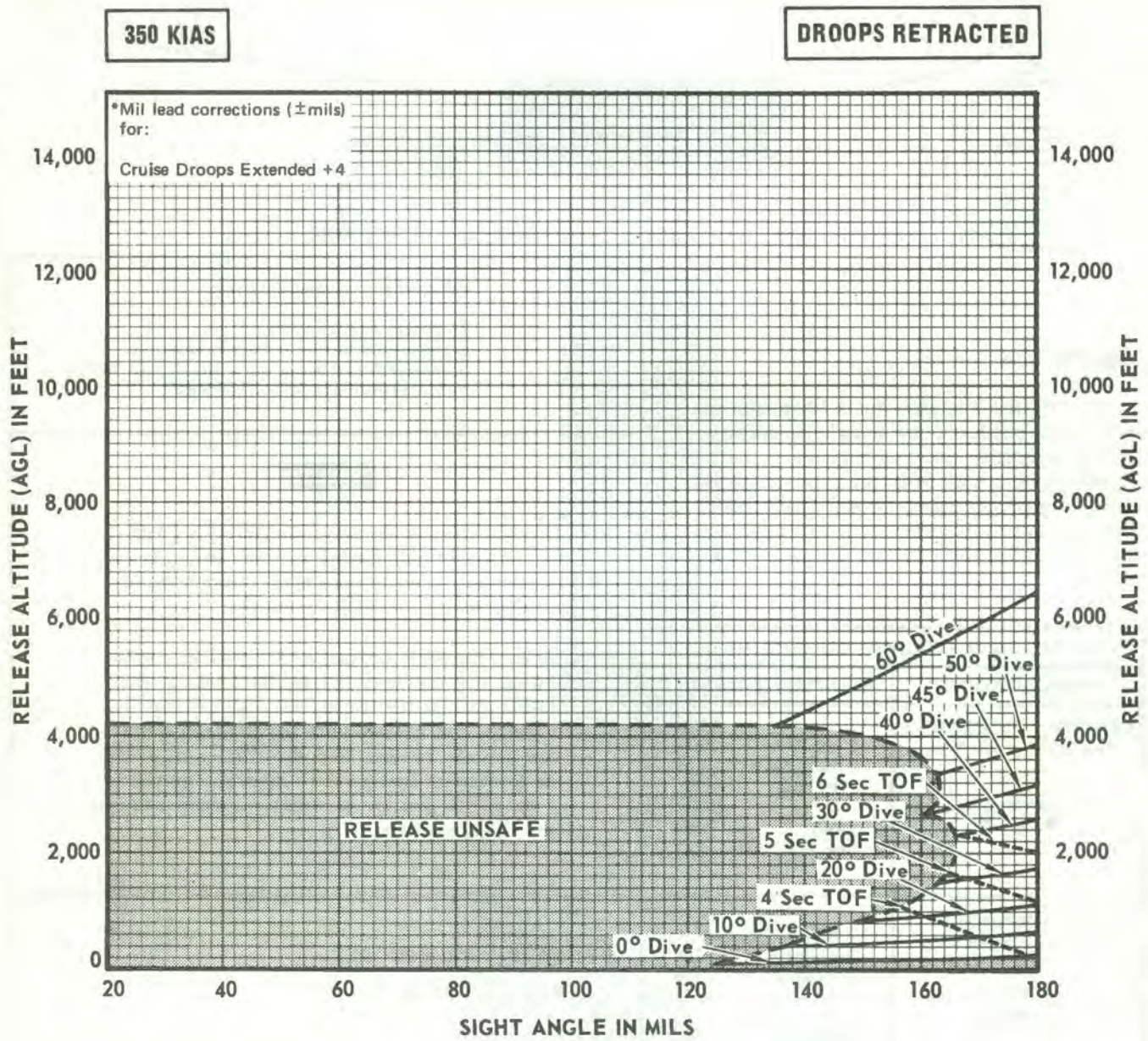
1. Restrictions – See Figure 2-2
2. Bomb Fuzing – NAVAIR 11-5A-17 (OP 2216)
3. Preflight Inspections – NAVAIR 01-45HH-75
4. Bomb Arming – NAVAIR 01-45HH-75

AZ-102-03-69

Figure 2–79

Mil Lead for Single Delivery

MK 77 FIRE BOMB



NOTE

Sight angles are based on 27,000 lb aircraft gross weight, 0 ft burst altitude, 0 ft target elevation, and 7.0 ft/sec ejection velocity. Released from Aero 7A ER.

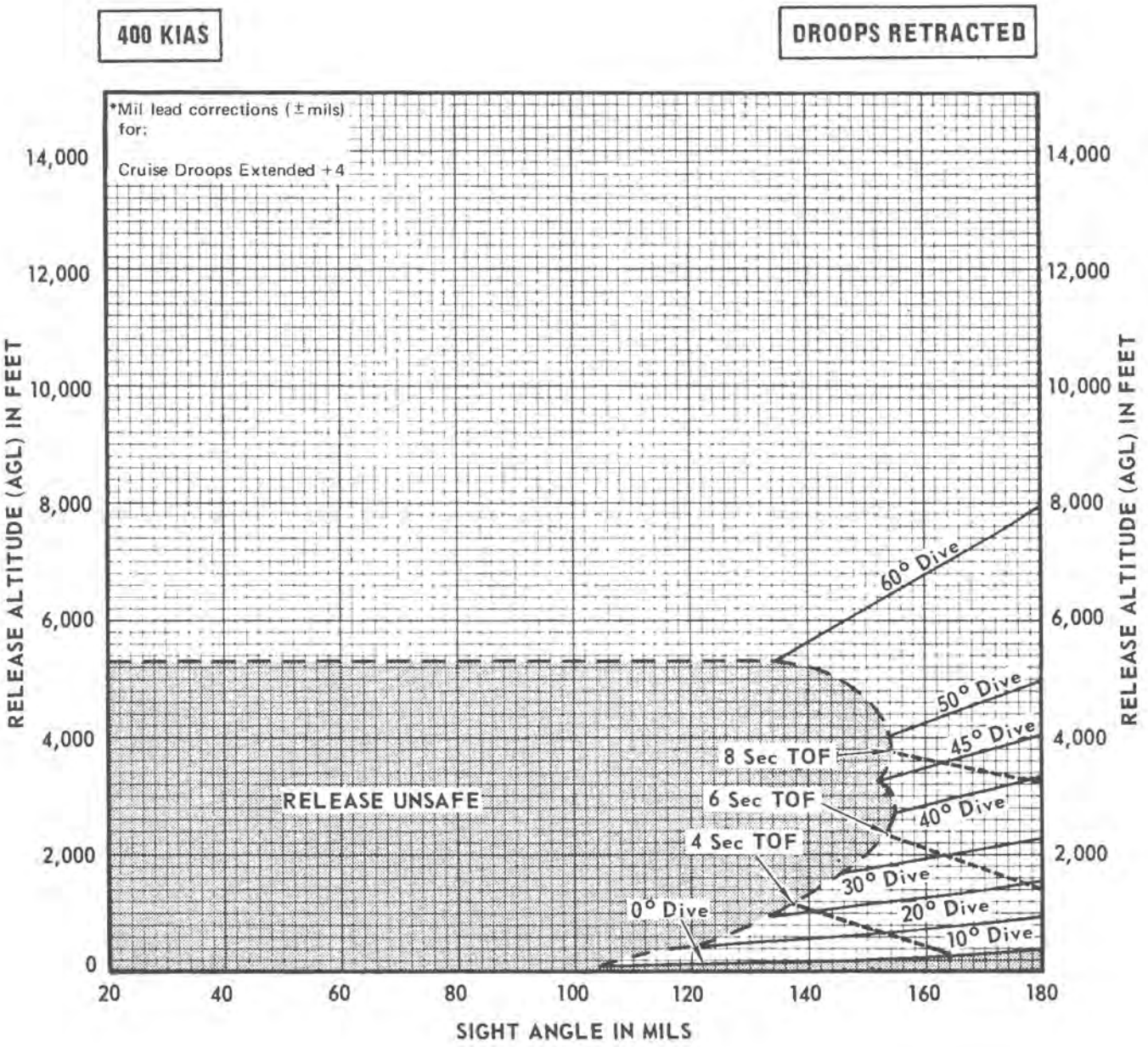
***For each 10°C increase (decrease) in temperature at release altitude, increase (decrease) the mil lead by 3 mils.**

AZ-223(1)-03-69

Figure 2-80 (Sheet 1)

Mil Lead for Single Delivery

MK 77 FIRE BOMB



NOTE

Sight angles are based on 27,000 lb aircraft gross weight, 0 ft burst altitude, 0 ft target elevation, and 7.0 ft/sec ejection velocity. Released from Aero 7A ER.

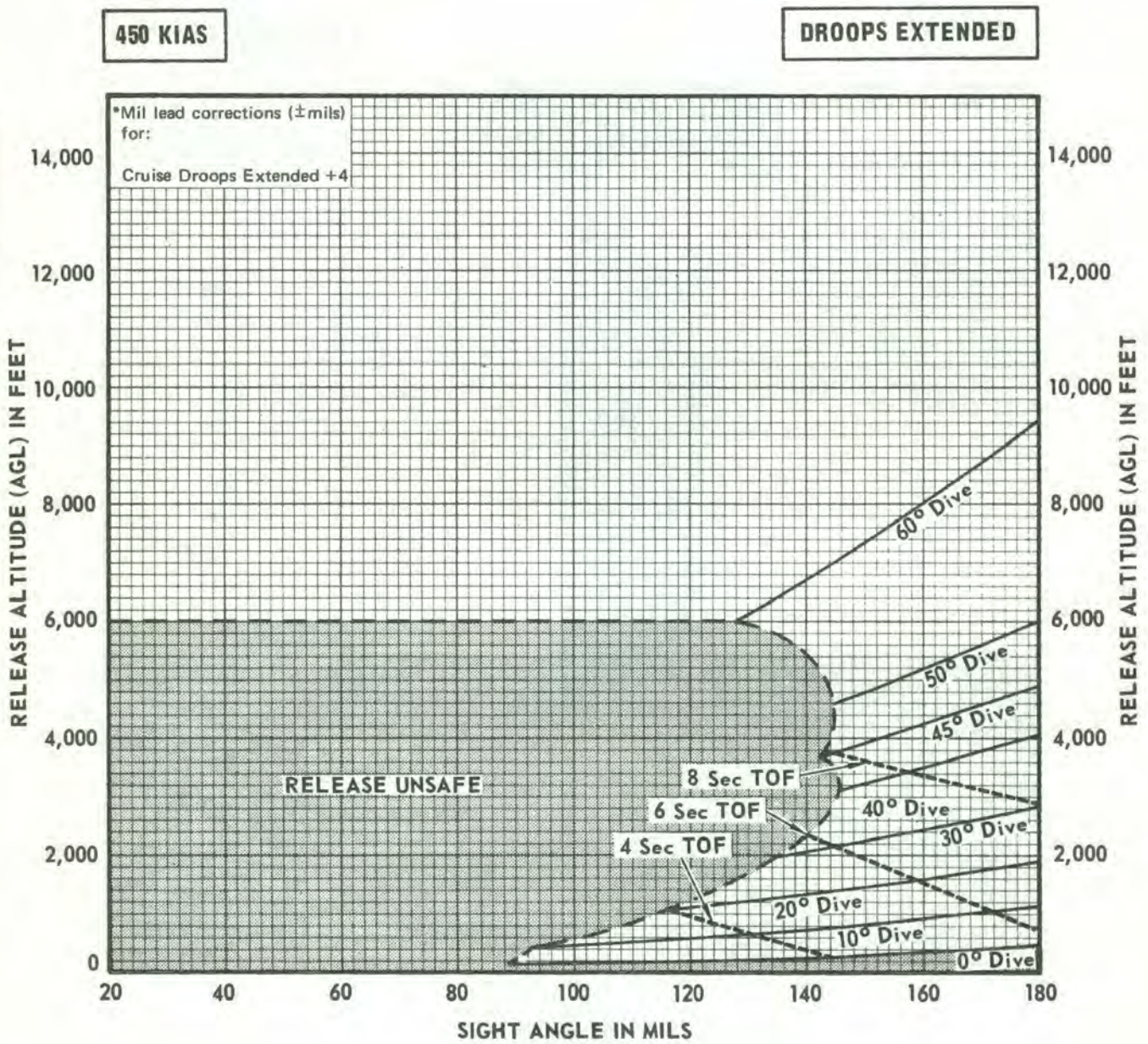
*For each 10°C increase (decrease) in temperature at release altitude, increase (decrease) the mil lead by 3 mils.

AZ-223(2)-03-69

Figure 2–80 (Sheet 2)

Mil Lead for Single Delivery

MK 77 FIRE BOMB



NOTE

Sight angles are based on 27,000 lb aircraft gross weight, 0 ft burst altitude, 0 ft target elevation, and 7.0 ft/sec ejection velocity. Released from Aero 7A ER.

*For each 10°C increase (decrease) in temperature at release altitude, increase (decrease) the mil lead by 3 mils.

AZ-223 (3)-03-69

Figure 2-80 (Sheet 3)

Tested Delivery Data

MK 77 FIRE BOMB

DIVE ANGLE	MIL LEAD		ENTRY			RELEASE			CORRECTION PER 10 KT OF DIRECT WIND – MILS		RELEASE ERROR SENSITIVITIES		
	EJECTED MILS	NON-EJECTED (MBR) – MILS	KIAS	ALTITUDE FT AGL	APPROX RPM %	KTAS	ALTITUDE FT AGL	ALTIMETER LAG – FT	Range	Cross	FT/KT KIAS	FT/100 FT ALTITUDE	FT/DEG DIVE ANGLE
LEVEL	105	——	435	100	94	450	100	0	2	27	3	700	Climb -400 Dive +150
10°	103	——	400	3,000	91	450	400	125	2	27	1.5	100	35

NOTES

1. Error sensitivities are applied as follows:

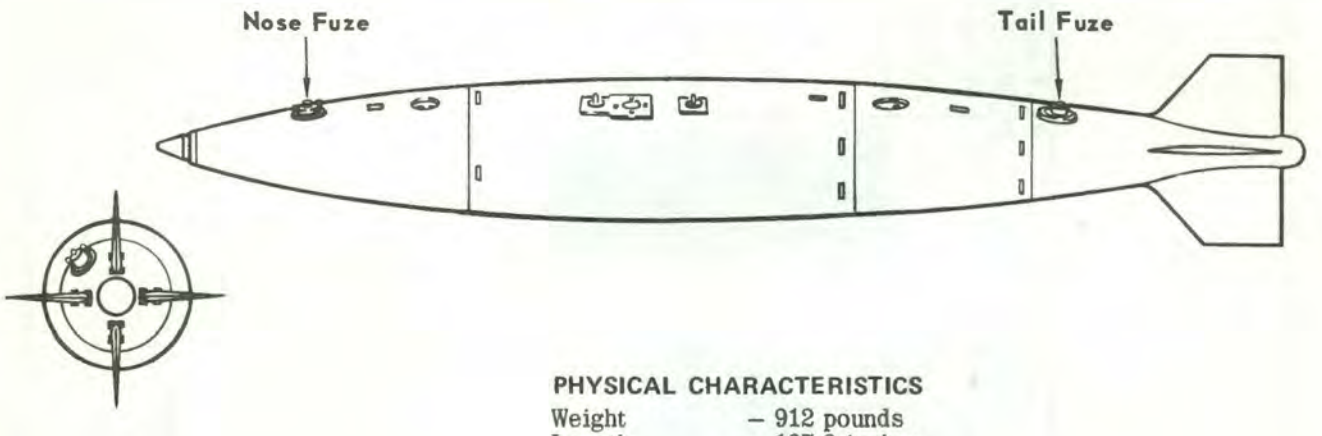
   Airspeed – Fast impacts long
   Slow impacts short
   Altitude – High impacts short
   Low impacts long
   Dive Angle – Steep impacts long
   Shallow impacts short

2. F-8 used in test was flown with cruise droop extended.

AZ-240-2-67

Figure 2–81

MK 79 Mod 1 Fire Bomb



PHYSICAL CHARACTERISTICS

Weight – 912 pounds
Length – 167.9 inches
Diameter – 19.6 inches
Suspension lugs – 14 inches apart

DESCRIPTION

The Mk 79 Mod 1 is a 1,000-pound fire bomb. The bomb is a low-drag design using thin metal. The bomb capacity is 112 gallons of gasoline and napalm mix. Once filled the bomb must be expended or jettisoned.

DROPPING PROCEDURES

(Mechanical)
1. Master Arm Sw – ON
2. Armament Sel Sw – Wing L or R
3. Mechanical Fuzing Sw – NOSE and TAIL
4. Stores Release Sw – DEPRESS

WING STATION LOADING CONFIGURATION

WING LOADING	EQUIPMENT-WEIGHT	
AERO 7A-1 SUSPENSION One Bomb Each Wing	2 MK 79	1824
	2 Aero 7A-1	104
	2 Pylons	350
	Total	2278
	One Wing Only	1139



NOTE

For simultaneous releases from Aero 7A-1 racks, the Triple-Multiple Rack Fire Mode switch in each pylon must be set to the DUAL position and the Arm Sel Sw in the WING-L position.

JETTISONING PROCEDURES

See JETTISONING this section.

REFERENCES

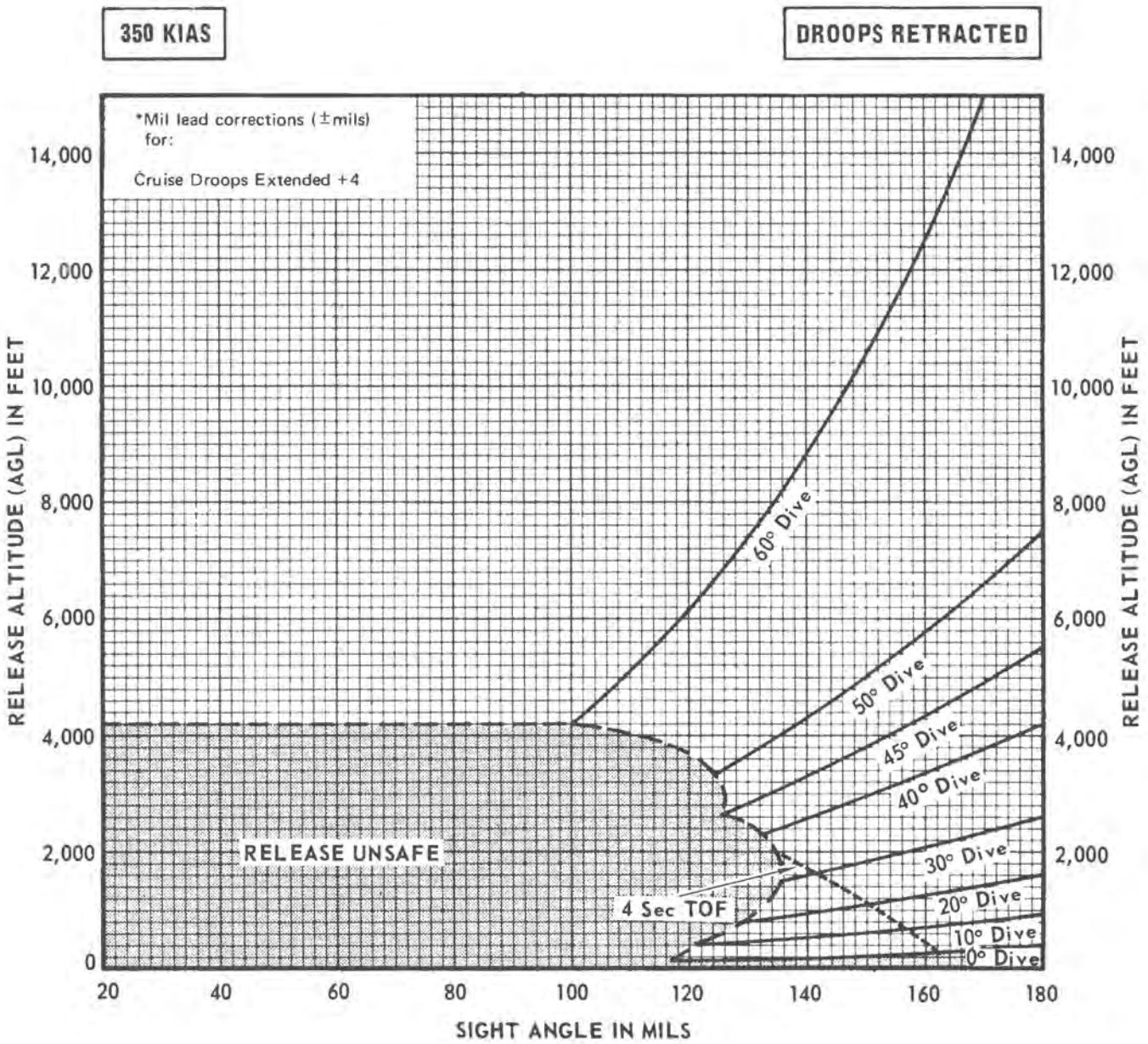
1. Restrictions – See Figure 2-2
2. Bomb Fuzing – NAVAIR 11-5A-17 (OP 2216)
3. Preflight Inspections – NAVAIR 01-45HH-75
4. Bomb Loading Procedures – NAVAIR 01-45HH-75

AZ-103-02-69

Figure 2–82

Mil Lead for Single Delivery

MK 79 MOD 1 FIRE BOMB



NOTE

Sight angles are based on 27,000 lb aircraft gross weight, 0 ft burst altitude, 0 ft target elevation, and 5.0 ft/sec ejection velocity.

Released from Aero 7A ER.

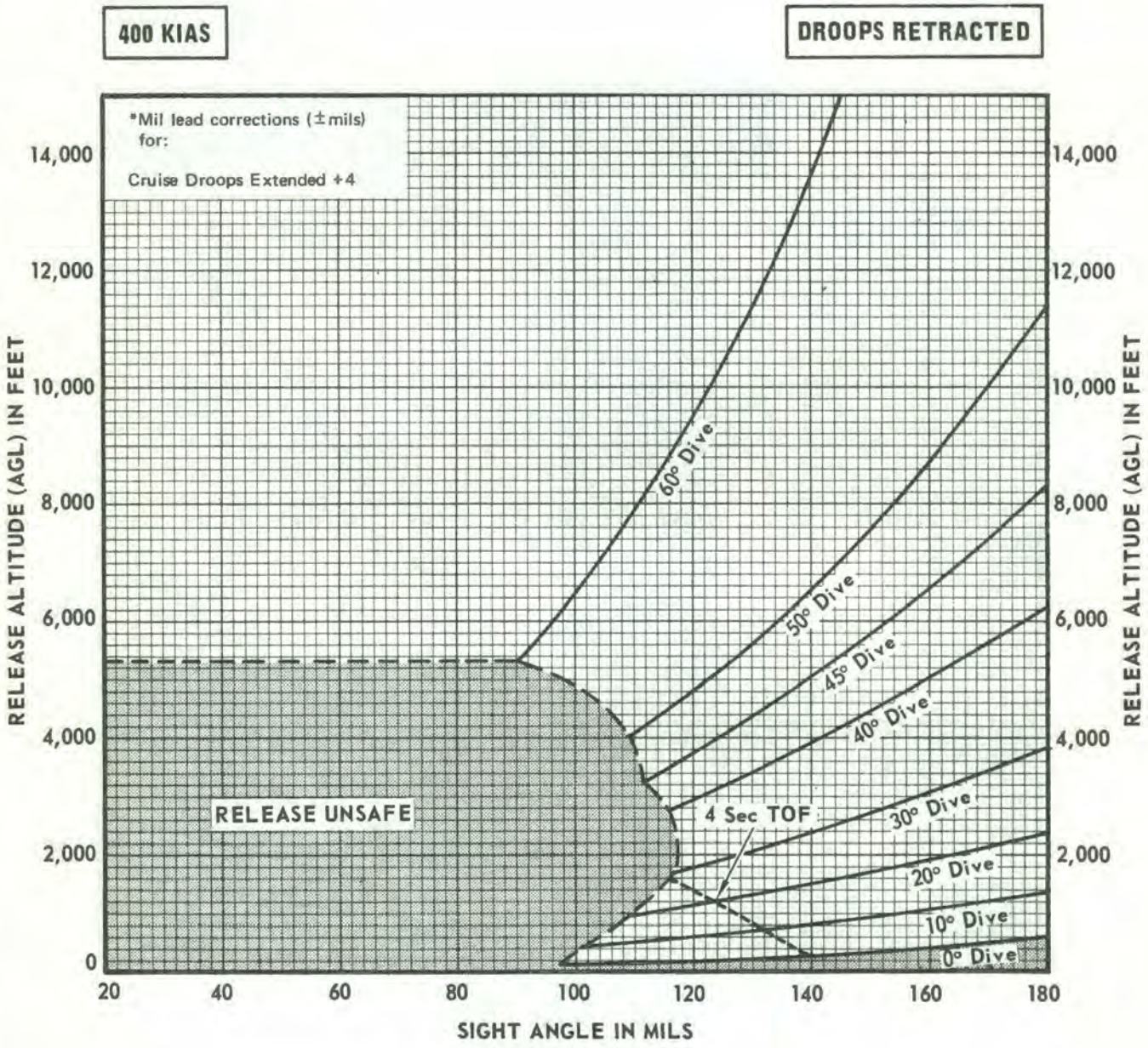
*For each 10°C increase (decrease) in temperature at release altitude, increase (decrease) the mil lead by 3 mils.

AZ-202(1)-03-69

Figure 2-83 (Sheet 1)

Mil Lead for Single Delivery

MK 79 MOD 1 FIRE BOMB



NOTE

Sight angles are based on 27,000 lb aircraft gross weight, 0 ft burst altitude, 0 ft target elevation, and 5.0 ft/sec ejection velocity.

Released from Aero 7A ER.

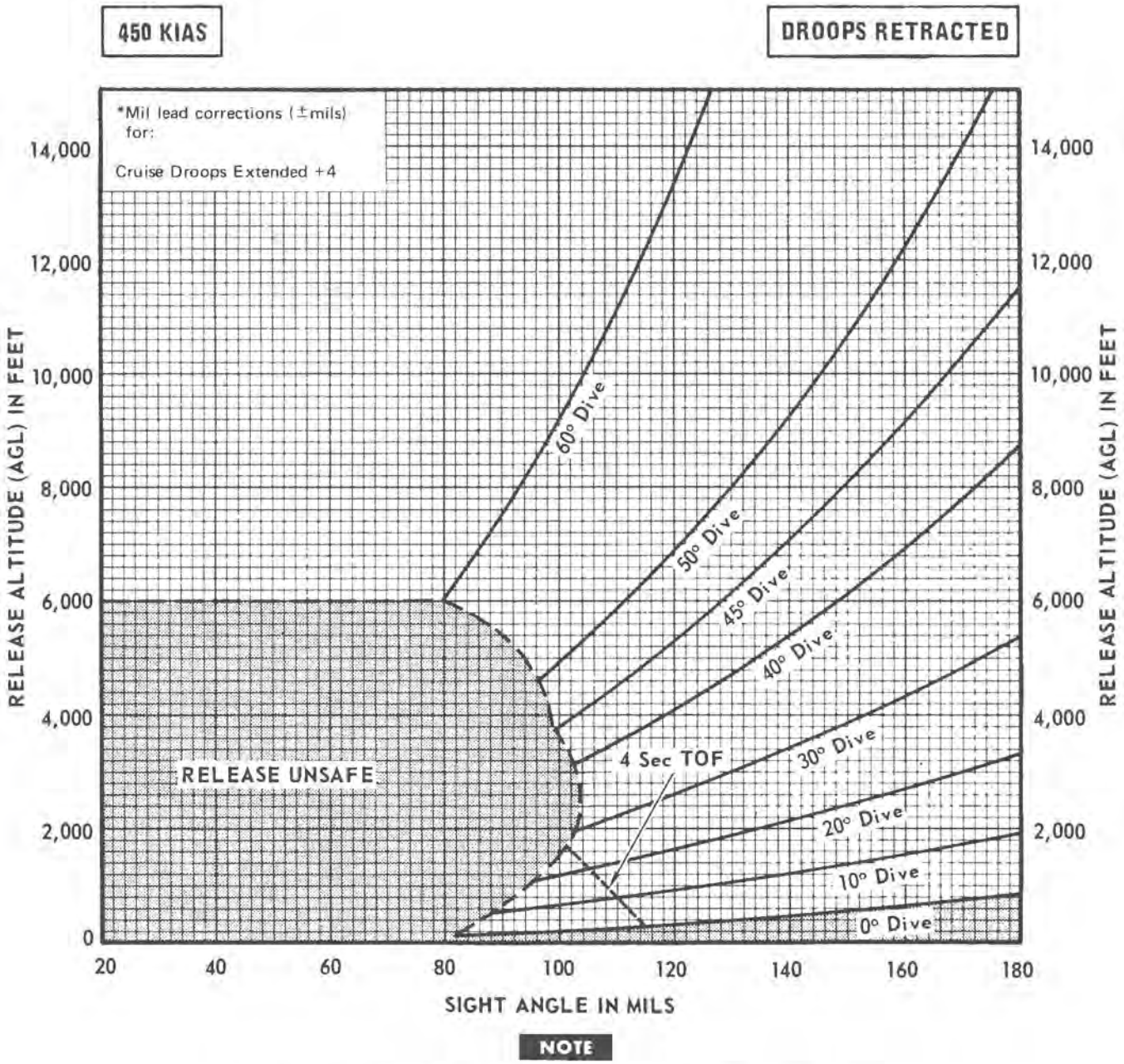
***For each 10°C increase (decrease) in temperature at release altitude, increase (decrease) the mil lead by 3 mils.**

AZ-202(2)-03-69

Figure 2-83 (Sheet 2)

Mil Lead for Single Delivery

MK 79 MOD 1 FIRE BOMB



NOTE

Sight angles are based on 27,000 lb aircraft gross weight, 0 ft burst altitude, 0 ft target elevation, and 5.0 ft/sec ejection velocity.

Released from Aero 7A ER.

*For each 10°C increase (decrease) in temperature at release altitude, increase (decrease) the mil lead by 3 mils.

AZ-20J(3)-03-69

Figure 2–83 (Sheet 3)

Tested Delivery Data

MK 79 FIRE BOMB

DIVE ANGLE	MIL LEAD		ENTRY			RELEASE			CORRECTION PER 10 KT OF DIRECT WIND – MILS		RELEASE ERROR SENSITIVITIES		
	EJECTED MILS	NON-EJECTED (MBR) – MILS	KIAS	ALTITUDE FT AGL	APPROX RPM %	KTAS	ALTITUDE FT AGL	ALTIMETER LAG – FT	Range	Cross	FT/KT KIAS	FT/100 FT ALTITUDE	FT/DEG DIVE ANGLE
LEVEL	115	——	435	100	94	450	100	0	2	27	3	700	Climb -400 Dive +150
10°	110	——	400	3,000	91	450	400	125	2	27	1.5	100	35

NOTES

1. Error sensitivities are applied as follows:

   Airspeed – Fast impacts long
   Slow impacts short

   Altitude – High impacts short
   Low impacts long

   Dive Angle – Steep impacts long
   Shallow impacts short

2. F-8 used in test was flown with cruise droop extended.

AZ-241-2-67

Figure 2-84

MK 76 Practice Bomb



PHYSICAL CHARACTERISTICS

Weight – 24 pounds
Length – 22.5 inches

PRACTICE BOMB SIGNAL

Mk 4 Mod 3
Firing Pin
Mk 1 Mod 0

DESCRIPTION

The Mk 76 is a 25-pound practice bomb. The bomb has a teardrop-shaped cast-metal body which is centrally bored. The fins are welded to a tail tube assembly which fits into the bored body. The firing pin assembly and signal are retained in the bore of the body by a cotter pin. This practice bomb is used to simulate many free-fall weapons. The Mod 2 bomb is illustrated; however the Mods 4 and 5 are currently in use.

DROPPING PROCEDURES

1. **Master Arm Sw – ON**
2. **Armament Sel Sw – Wing L or R**
3. **Stores Release Sw – DEPRESS**

WING STATION LOADING CONFIGURATIONS

WING LOADING	EQUIPMENT-WEIGHT	
PMBR SUSPENSION **Six Bombs Each Wing**	**12 MK 76**	**288**
	2 Aero 7A-1	**104**
	2 Pylons	**350**
	2 PMBR	**174**
	Total	**916**
	One Wing Only	**458**



REFERENCES

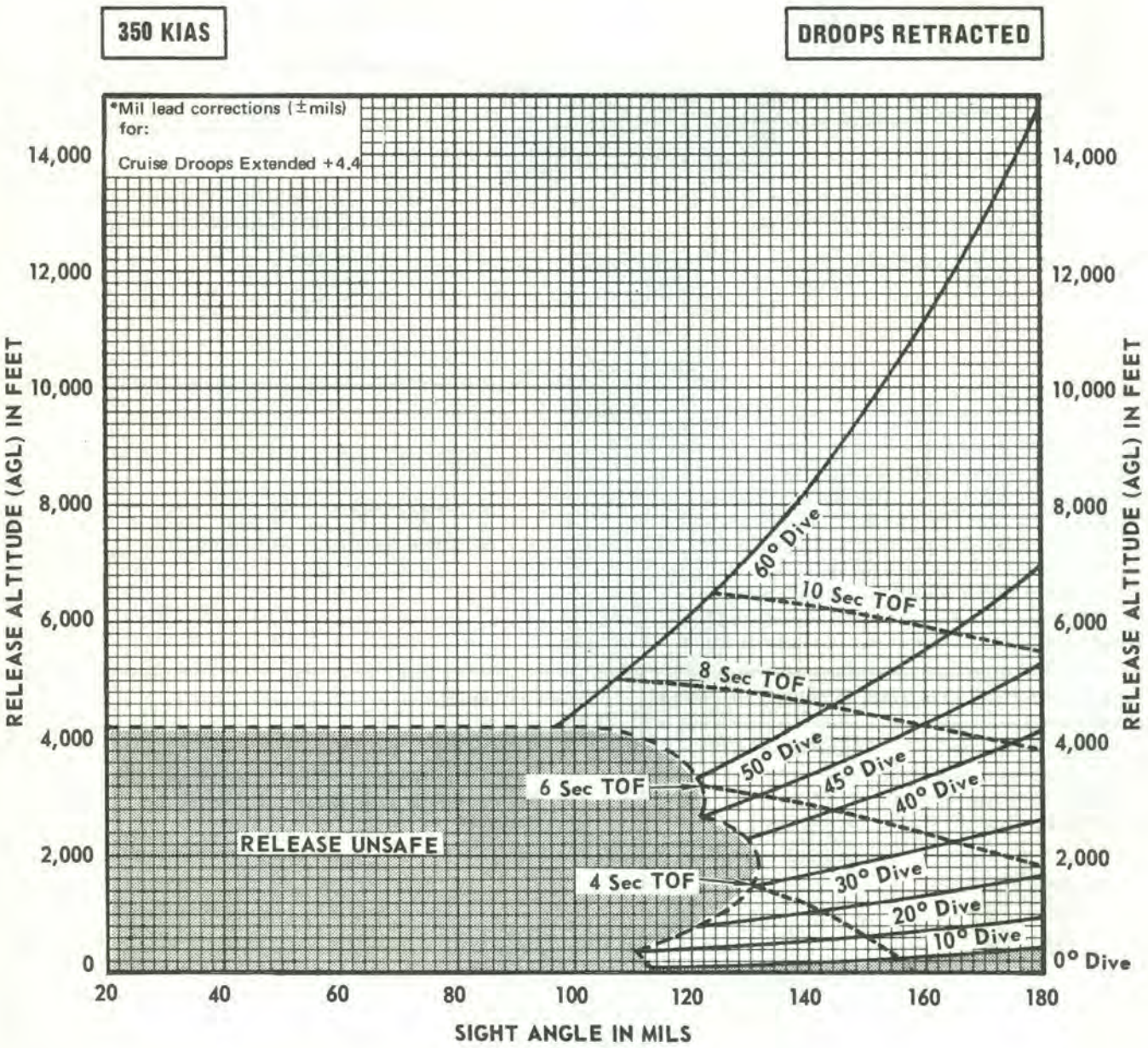
1. Restrictions – See Figure 2-2
2. Preflight Inspection – NAVAIR 01-45HH-75
3. Bomb Loading Procedures – NAVAIR 01-45HH-75

AZ-130-03-69

Figure 2–85

Mil Lead for Single Delivery

MK 76 MOD 5 PRACTICE BOMB



NOTE

Sight angles are based on 27,000 lb aircraft gross weight, 0 ft burst altitude, 0 ft target elevation, and 0.0 ft/sec ejection velocity. Released from PMBR A/A 37B-3.

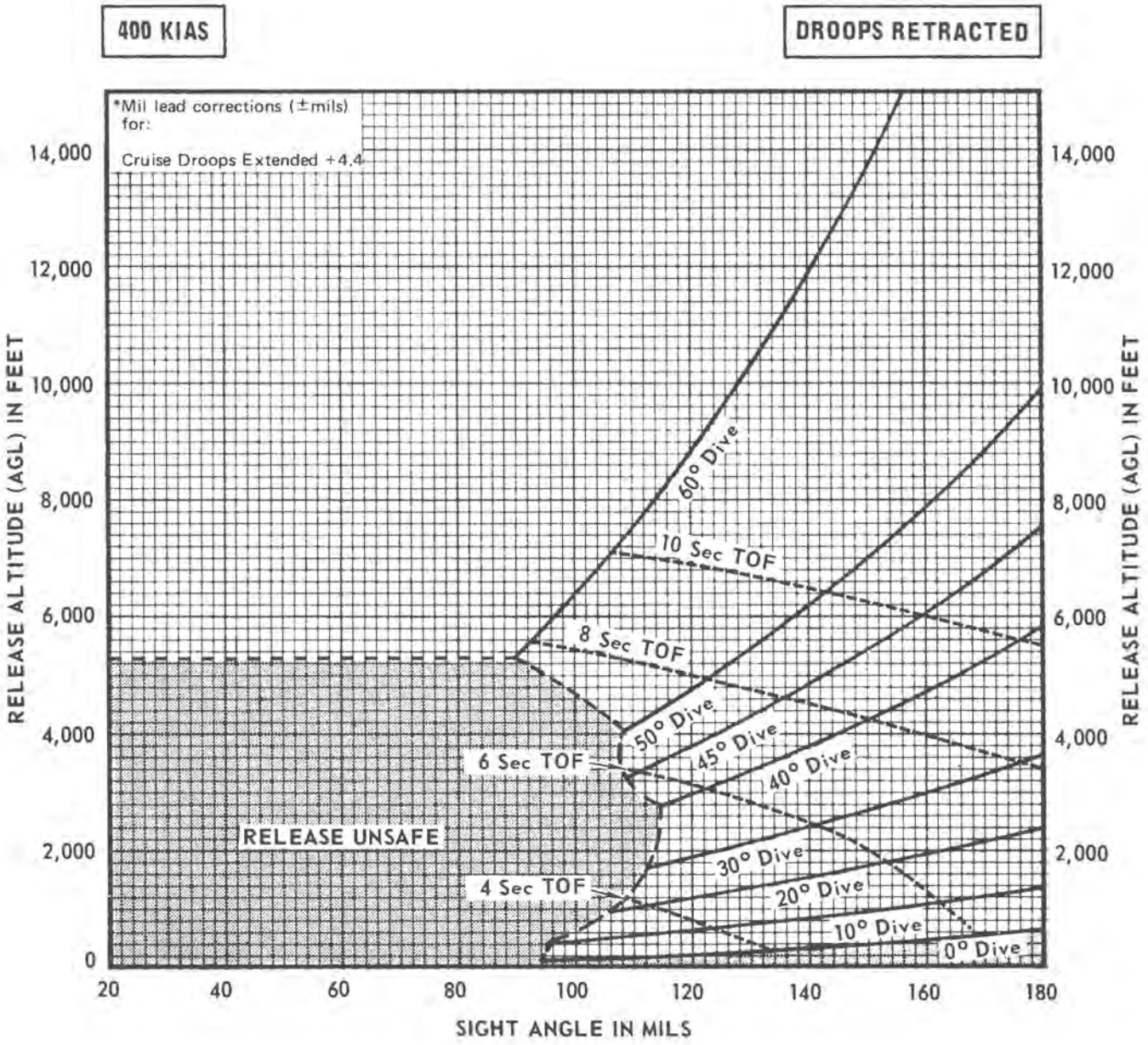
*For each 10°C increase (decrease) in temperature at release altitude, increase (decrease) the mil lead by 3 mils.

AZ-203(1)-03-69

Figure 2-86 (Sheet 1)

Mil Lead for Single Delivery

MK 76 MOD 5 PRACTICE BOMB



NOTE

Sight angles are based on 27,000 lb aircraft gross weight, 0 ft burst altitude, 0 ft target elevation, and 0.0 ft/sec ejection velocity. Released from PMBR A/A 37B-3.

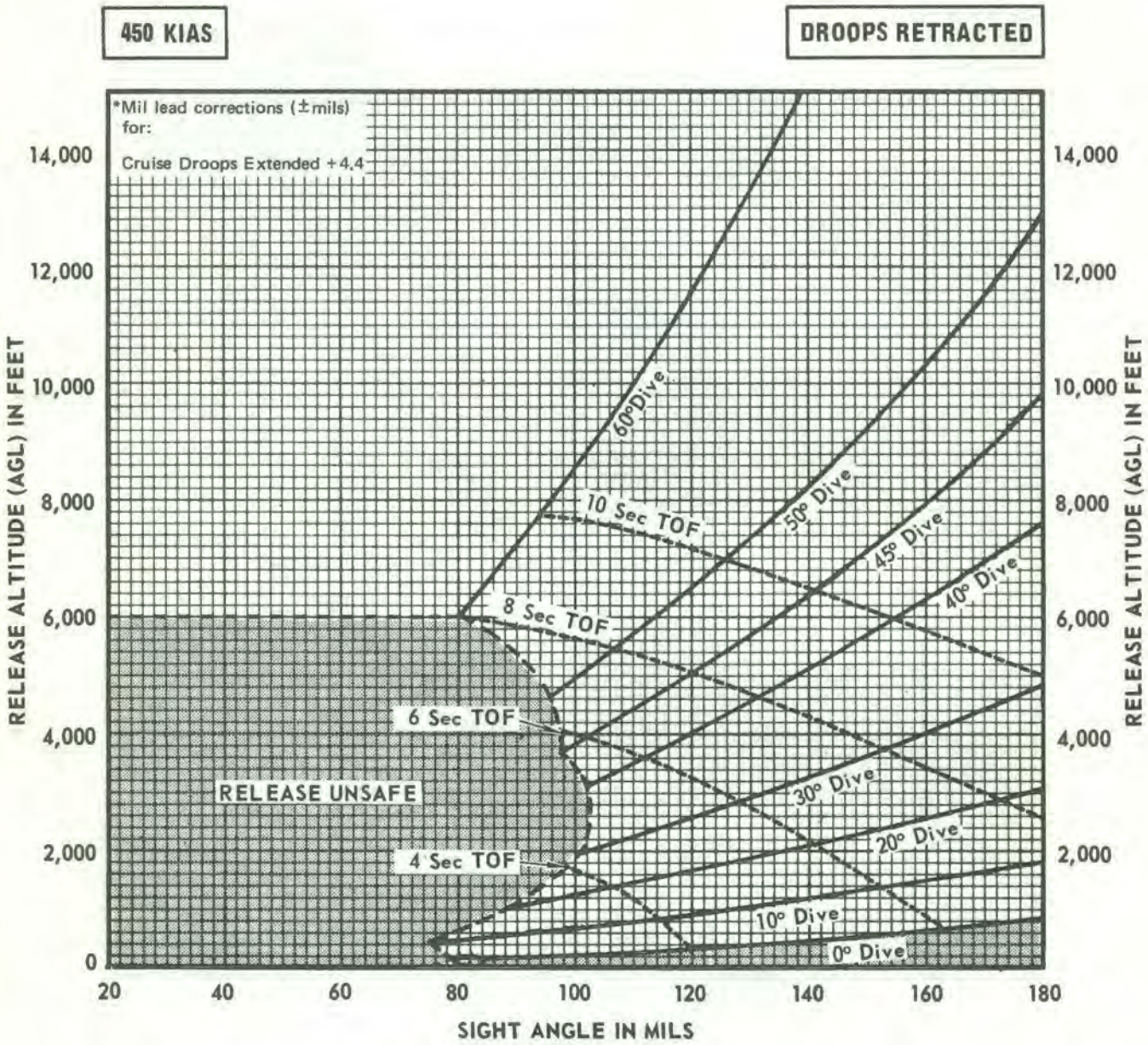
*For each 10°C increase (decrease) in temperature at release altitude, increase (decrease) the mil lead by 3 mils.

AZ-203(21-03-69

Figure 2-86 (Sheet 2)

Mil Lead for Single Delivery

MK 76 MOD 5 PRACTICE BOMB



NOTE

Sight angles are based on 27,000 lb aircraft gross weight, 0 ft burst altitude, 0 ft target elevation, and 0.0 ft/sec ejection velocity. Released from PMBR A/A 37B-3.

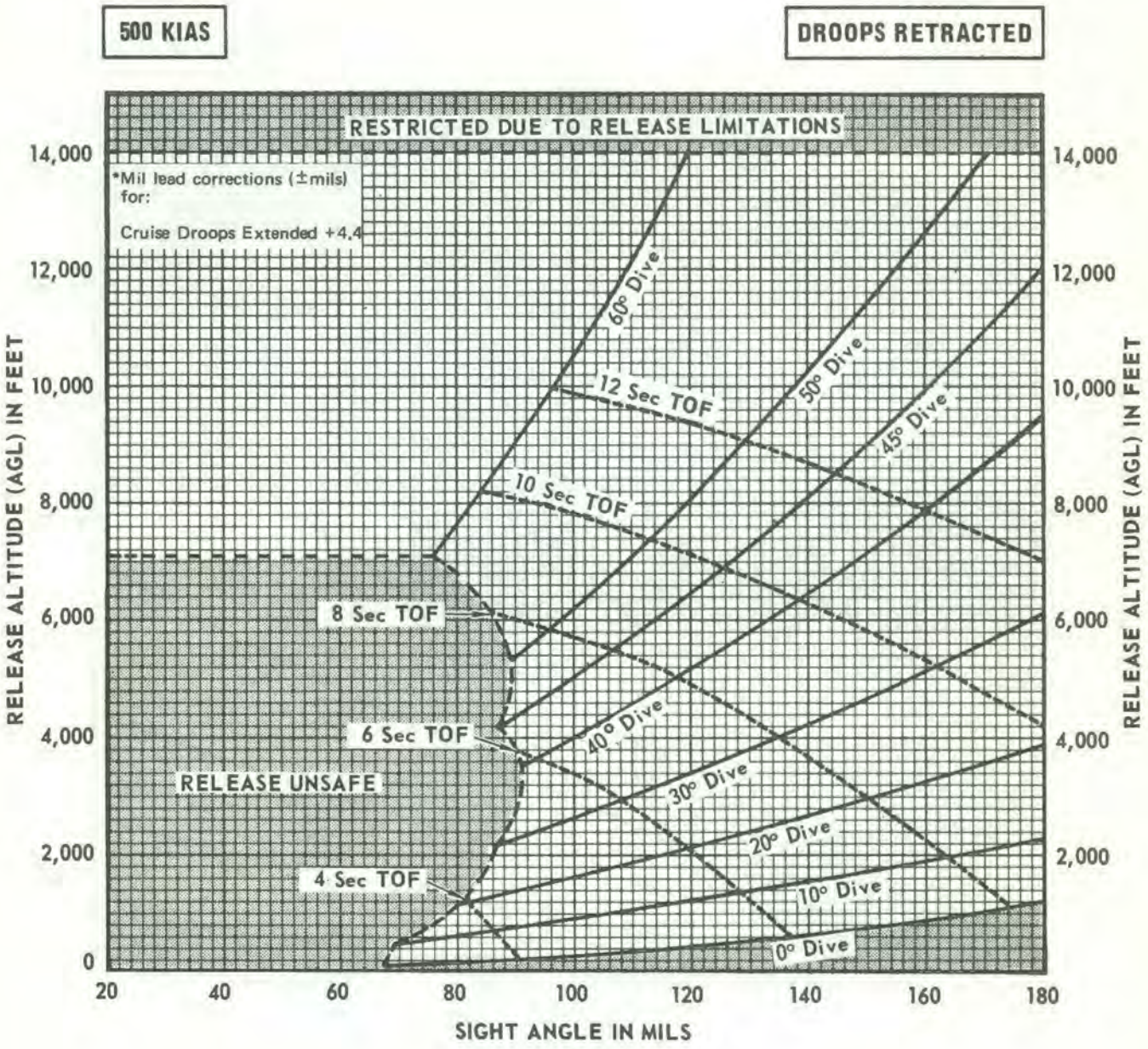
***For each 10°C increase (decrease) in temperature at release altitude, increase (decrease) the mil lead by 3 mils.**

AZ-203(3)-03-69

Figure 2-86 (Sheet 3)

Mil Lead for Single Delivery

MK 76 MOD 5 PRACTICE BOMB



NOTE

Sight angles are based on 27,000 lb aircraft gross weight, 0 ft burst altitude, 0 ft target elevation, and 0.0 ft/sec ejection velocity. Released from PMBR A/A 37B-3.

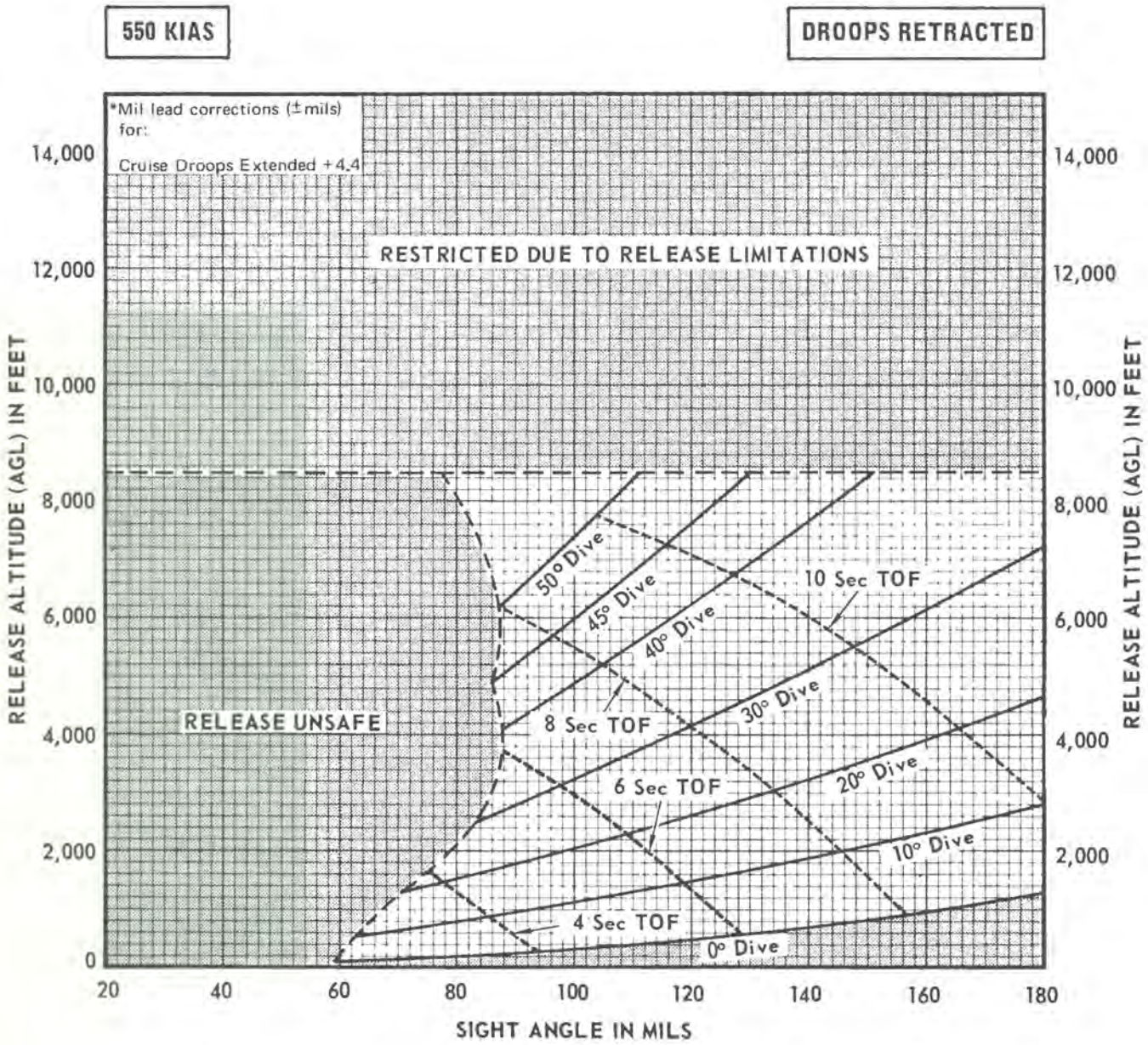
***For each 10°C increase (decrease) in temperature at release altitude, increase (decrease) the mil lead by 3 mils.**

AZ-203(4)-03-69

Figure 2-86 (Sheet 4)

Mil Lead for Single Delivery

MK 76 MOD 5 PRACTICE BOMB



NOTE

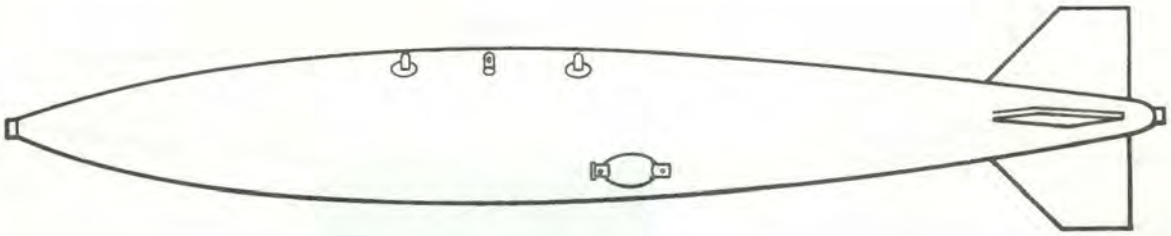
Sight angles are based on 27,000 lb aircraft gross weight, 0 ft burst altitude, 0 ft target elevation, and 0.0 ft/sec ejection velocity. Released from PMBR A/A 37B-3.

*For each 10°C increase (decrease) in temperature at release altitude, increase (decrease) the mil lead by 3 mils.

AZ-203(5)-03-69

Figure 2-86 (Sheet 5)

MK 86 Practice Bomb



PHYSICAL CHARACTERISTICS

Weight	
(Loaded – Wet Sand)	– 217 pounds
(Loaded – Water)	– 141 pounds
Length	– 76 inches
Diameter	– 9 inches
Suspension lugs	– 14 inches apart

PRACTICE BOMB SIGNAL

MK 4 MOD 3

Firing Pin
MK 1 MOD 0

DESCRIPTION

The MK 86 is a low-drag practice bomb of similar size and shape as the MK 80 series low-drag general purpose bombs. The bomb is of thin-case construction with internal reinforcement for the sway brace and ejection areas.

For delivery data refer to the MK 81 conical fin delivery data tables.

DROPPING PROCEDURES

1. Master Arm Sw – ON
2. Armament Sel Sw – WING L or R
3. Stores Release Sw – DEPRESS

WING STATION LOADING CONFIGURATIONS

WING LOADING	EQUIPMENT-WEIGHT
AERO 7A SUSPENSION One Bomb Each Wing 	2 MK 86 434 (282) 2 Aero 7A-1 104 104 2 Pylons 350 350 Total 888 (736) One Wing Only 444 (368)
MBR SUSPENSION Two Bombs Each Wing 	4 MK 86 868 (564) 2 Aero 7A-1 104 104 2 Pylons 350 350 2 MBR 318 318 Total 1640 (1326) One Wing Only 820 (663)

NOTE

For simultaneous releases from the Aero 7A-1 racks the Triple-Multiple Rack Fire Mode switch in each pylon must be set to the DUAL position.

JETTISONING PROCEDURES

See JETTISONING this section

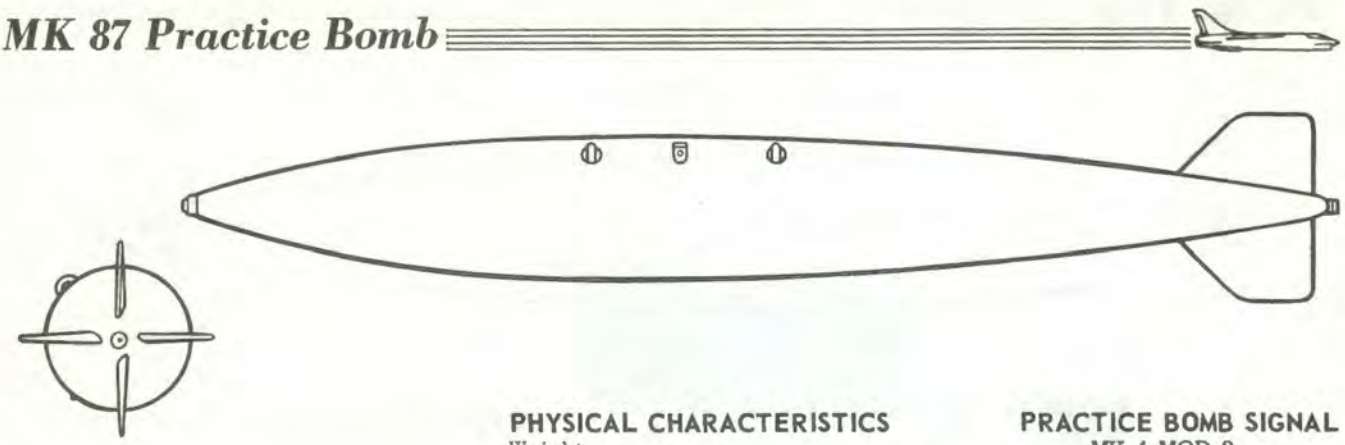
REFERENCES

1. Restrictions – See Figure 2-2
2. Bomb Fuzing – NAVAIR 11-5A-17 (OP 2216)
3. Preflight Inspection – NAVAIR 01-45HH-75
4. Bomb Loading Procedures – NAVAIR 01-45HH-75

AZ-104-03-69

Figure 2–87

MK 87 Practice Bomb



PHYSICAL CHARACTERISTICS

Weight	
(Loaded – Wet Sand)	– 333 pounds
(Loaded – Water)	– 221 pounds
Length	– 90.89 inches
Diameter	– 10.75 inches
Suspension lugs	– 14 inches apart

PRACTICE BOMB SIGNAL

MK 4 MOD 3

Firing Pin
MK 1 MOD 0

DESCRIPTION

The MK 87 is a low-drag practice bomb of similar size and shape as the MK 82 general purpose bomb. The bomb is of thin case construction with internal reinforcement for the sway brace and ejection areas. For delivery data refer to the MK 82 conical fin delivery data tables.

WING STATION LOADING CONFIGURATIONS

WING LOADING	EQUIPMENT-WEIGHT
AERO 7A SUSPENSION **One Bomb Each Wing** 	2 MK 87 666 (442) 2 Aero 7A 104 104 2 Pylons 350 350 Total 1120 (896) One Wing Only 560 (448)
MBR SUSPENSION **Two Bombs Each Wing** 	4 MK 87 1332 (884) 2 Aero 7A 104 104 2 Pylons 350 350 2 MBR 318 318 Total 2104 (1656) One Wing Only 1052 (828)

DROPPING PROCEDURES

1. Master Arm Sw – ON
2. Armament Sel Sw – WING L or R
3. Stores Release Sw – DEPRESS

NOTE

For simultaneous releases from the Aero 7A-1 racks the Triple-Multiple Rack Fire Mode switch in each pylon must be set to the DUAL position.

JETTISONING PROCEDURES

See JETTISONING this section.

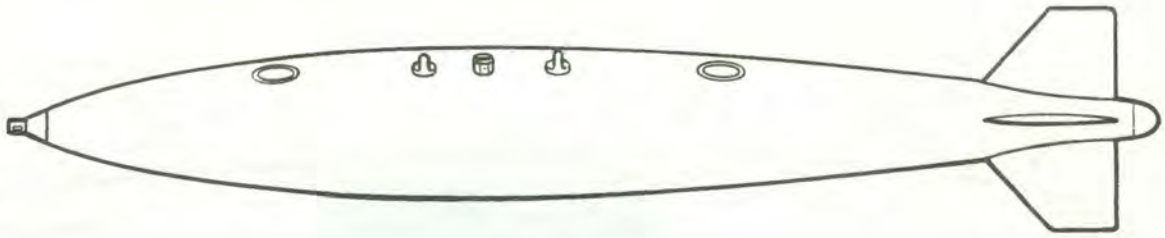
REFERENCES

1. Restrictions – See Figure 2-2
2. Bomb Fuzing – NAVAIR 11-5A-17 (OP 2216)
3. Preflight Inspection – NAVAIR 01-45HH-75
4. Bomb Loading Proceudres – NAVAIR 01-45HH-75

AZ–105–03–69

Figure 2–88

MK 88 Practice Bomb





PHYSICAL CHARACTERISTICS

Weight (Loaded – Wet Sand) – 783 pounds
(Loaded – Water) – 458 pounds
Length – 119.8 inches
Diameter – 14 inches
Suspension lugs – 14 inches apart

PRACTICE BOMB SIGNAL

MK 4 MOD 3

Firing Pin
MK 1 MOD 0

DESCRIPTION

The MK 88 is a low-drag practice bomb of the same size and shape as the MK 83 general purpose bomb. The bomb is of thin case construction with internal reinforcement for the sway brace and ejection areas.
For delivery data refer to the MK 83 conical fin delivery data tables.

WING STATION LOADING CONFIGURATION

WING LOADING	EQUIPMENT-WEIGHT
AERO 7A SUSPENSION One Bomb Each Wing 	2 MK 88 1566 (916) 2 Aero 7A 104 104 2 Pylons 350 350 Total 2020 (1370) One Wing 1010 (685)
TER SUSPENSION Two Bombs Each Wing 	4 MK 88 3132 (1832) 2 Aero 7A 104 104 2 Pylons 350 350 Total 3586 (2286) One Wing 1798 (1143)
MER SUSPENSION Two Bombs Each Wing 	4 MK 88 3132 (1832) 2 Aero 7A 104 104 2 Pylons 350 350 Total 3586 (2286) One Wing 1798 (1143)

DROPPING PROCEDURES

1. Master Arm Sw – ON
2. Armament Sel Sw – Wing L or R
3. Stores Release Sw – DEPRESS

NOTE

For simultaneous releases from the Aero 7A-1 racks, the Triple-Multiple Rack Fire Mode switch in each pylon must be set to the DUAL position.

JETTISONING PROCEDURES

See JETTISONING this section.

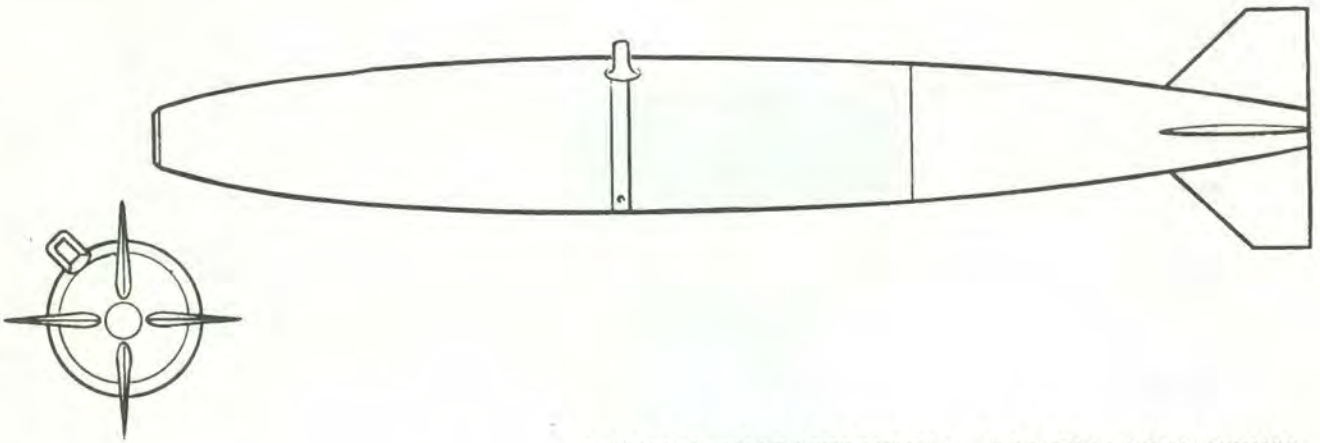
REFERENCES

1. Restrictions – See Figure 2-2
2. Bomb Fuzing – NAVAIR 11-5A-17 (OP 2216)
3. Preflight Inspection – NAVAIR 01-45HH-75
4. Bomb Loading Procedures – NAVAIR 01-45HH-75

AZ-106-03-69

Figure 2–89

MK 89 Practice Bomb



DESCRIPTION

The MK 89 is a low-drag practice bomb, similar in shape to the low-drag series of general purpose bombs. The cast iron body is slender, with a long, pointed nose. The conical type fin assembly has the tail fins canted 2 degrees to impart spin to the bomb to obtain consistent trajectories.

PHYSICAL CHARACTERISTICS

Weight	– 57 pounds
Length	– 31.3 inches
Diameter	– 4 inches
Suspension lug	– Center

PRACTICE BOMB SIGNAL

MK 4 MOD 3

WING STATION LOADING CONFIGURATIONS

WING LOADING	EQUIPMENT-WEIGHT	
PMBR SUSPENSION Three Bombs Each Wing	6 MK 89	342
	2 Aero 7A-1	104
	2 Pylons	350
	2 PMBR	174
	Total	970
	One Wing Only	485

DROPPING PROCEDURES

1. Master Arm Sw – ON
2. Armament Sel Sw – Wing L or R
3. Stores Release Sw – DEPRESS

NOTE

For simultaneous releases from both wings the Triple-Multiple Rack Fire Mode switch in each pylon must be set to the DUAL position.

JETTISONING PROCEDURES

See JETTISONING this section.

REFERENCES

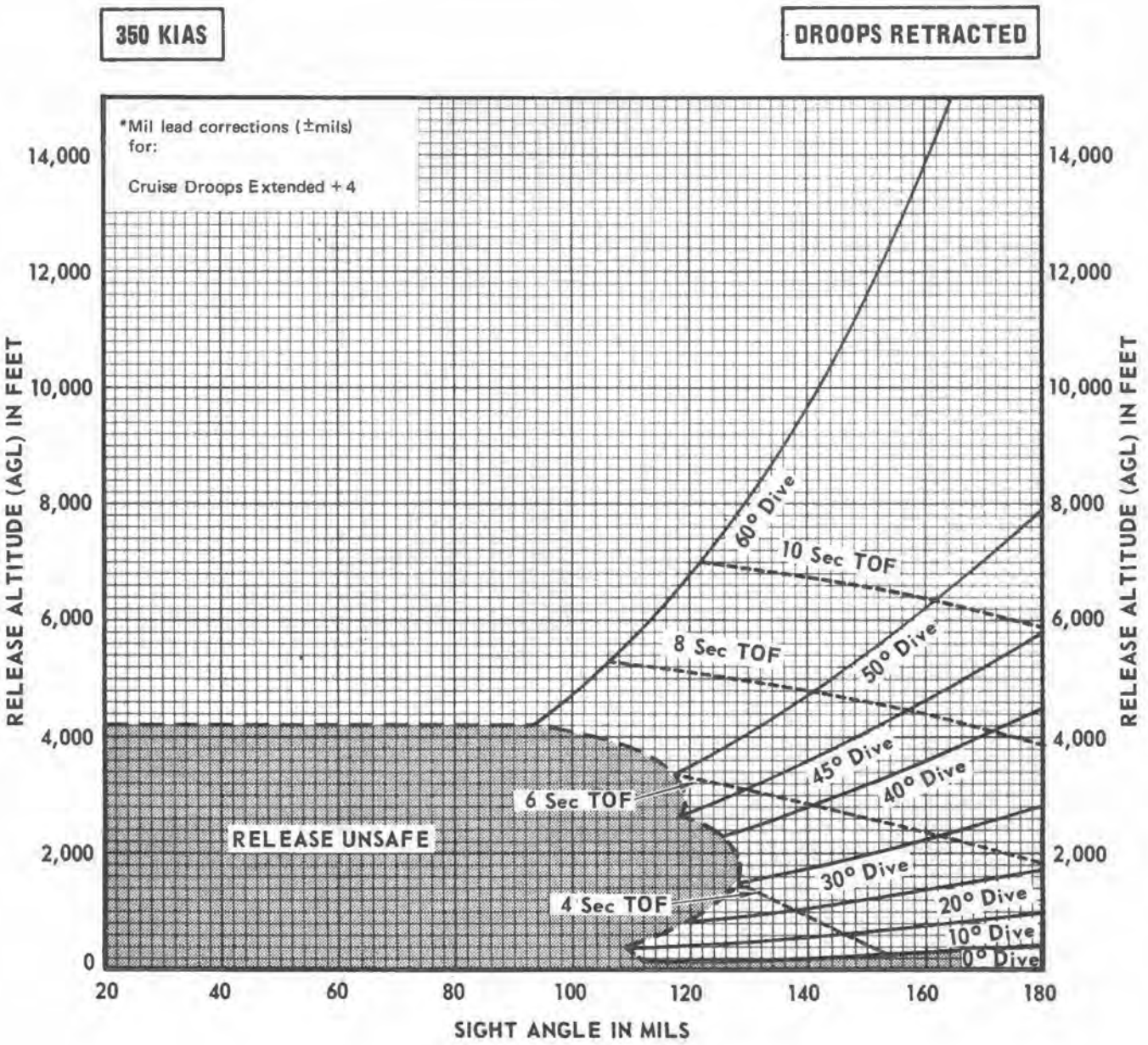
1. Restrictions – See Figure 2-2
2. Bomb Fuzing – NAVAIR 11-5A-17 (OP 2216)
3. Preflight Inspection – NAVAIR 01-45HH-75
4. Bomb Loading Procedures – NAVAIR 01-45HH-75

AZ-107-03-69

Figure 2–90

Mil Lead for Single Delivery

MK 89 MOD 0 PRACTICE BOMB



NOTE

Sight angles are based on 27,000 lb aircraft gross weight, 0 ft burst altitude, 0 ft target elevation, and 0.0 ft/sec ejection velocity. Released from PMBR A/A 37B-3.

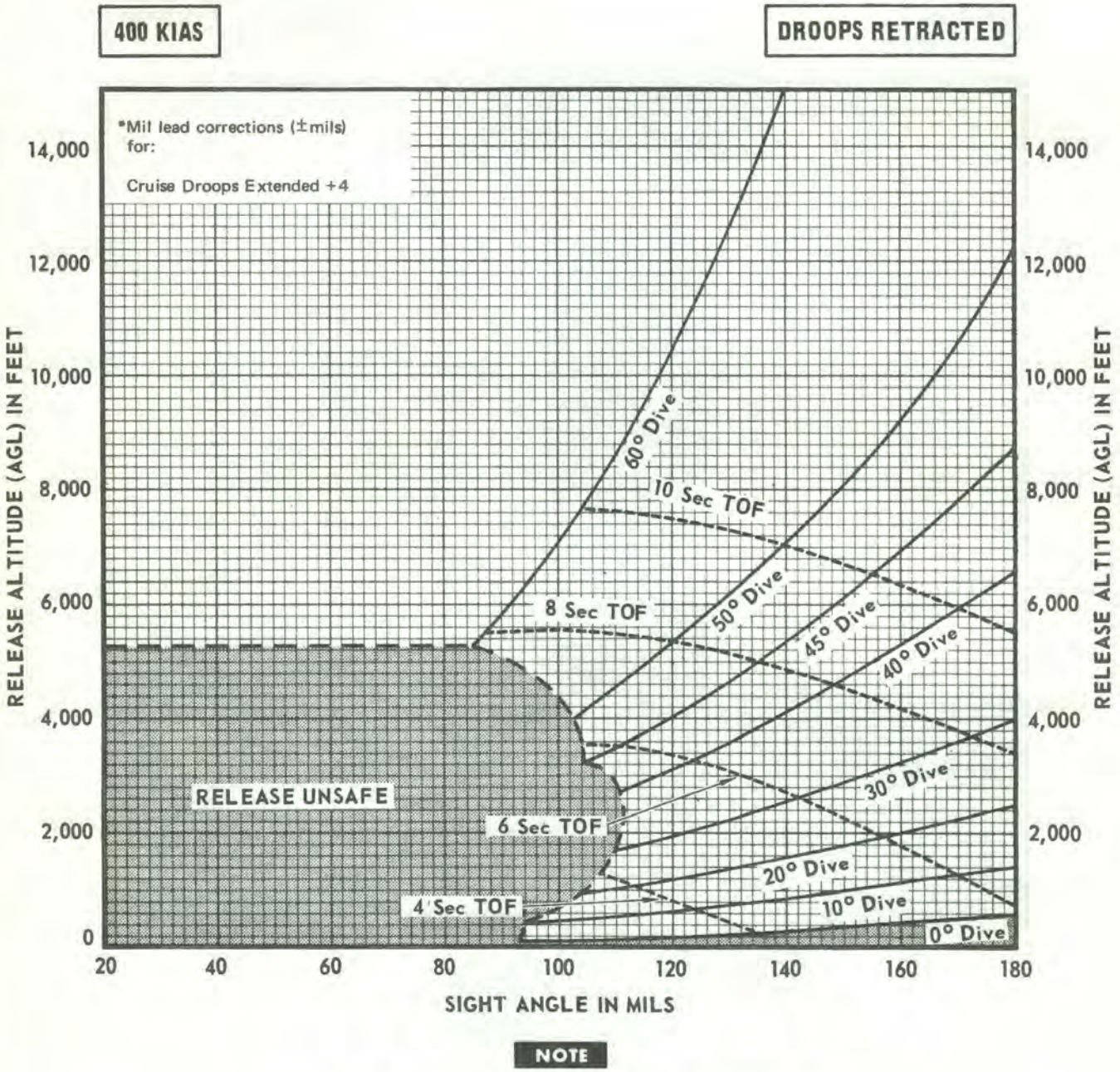
***For each 10° C increase (decrease) in temperature at release altitude, increase (decrease) the mil lead by 3 mils.**

AZ-200(1)-3-69

Figure 2-91 (Sheet 1)

Mil Lead for Single Delivery

MK 89 MOD 0 PRACTICE BOMB



NOTE

Sight angles are based on 27,000 lb aircraft gross weight, 0 ft burst altitude, 0 ft target elevation, and 0.0 ft/sec ejection velocity. Released from PMBR A/A 37B-3.

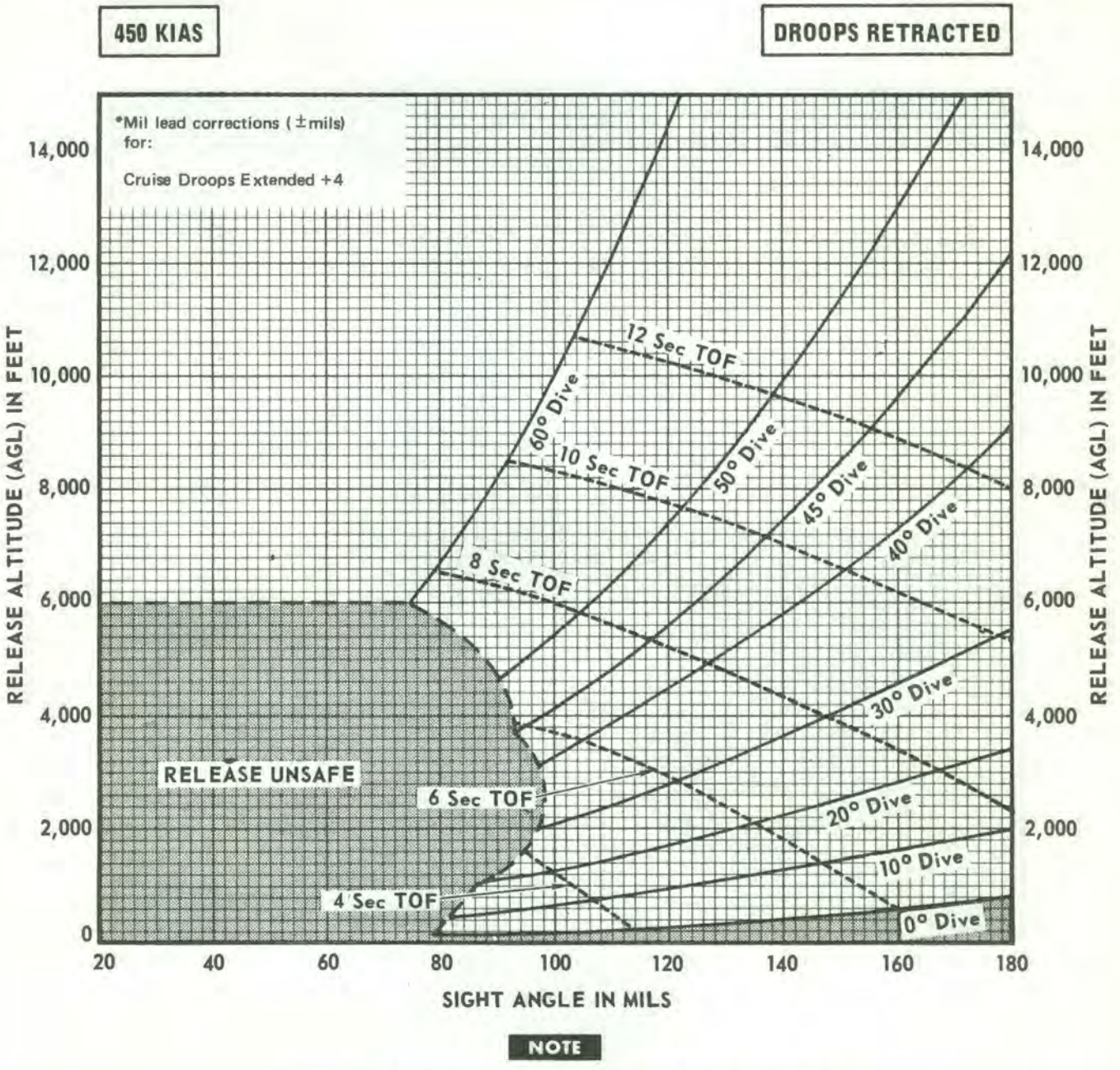
***For each 10°C increase (decrease) in temperature at release altitude, increase (decrease) the mil lead by 3 mils.**

AZ-200(2)-3-69

Figure 2-91 (Sheet 2)

Mil Lead for Single Delivery

MK 89 MOD 0 PRACTICE BOMB



NOTE

Sight angles are based on 27,000 lb aircraft gross weight, 0 ft burst altitude, 0 ft target elevation, and 0.0 ft/sec ejection velocity. Released from PMBR A/A 37B-3.

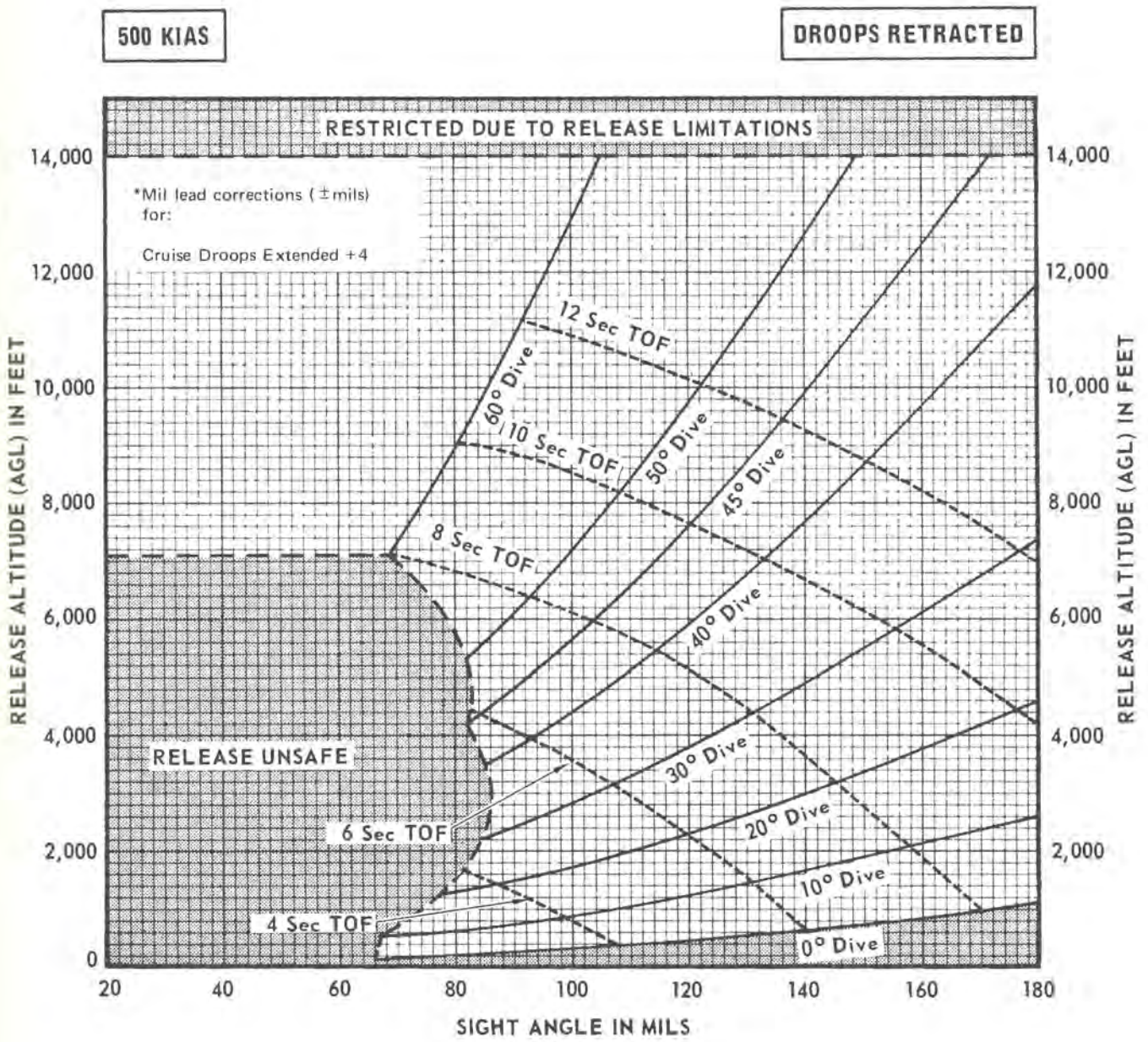
*For each 10°C increase (decrease) in temperature at release altitude, increase (decrease) the mil lead by 3 mils.

AZ-200(3)-3-69

Figure 2-91 (Sheet 3)

Mil Lead for Single Delivery

MK 89 MOD 0 PRACTICE BOMB



NOTE

Sight angles are based on 27,000 lb aircraft gross weight, 0 ft burst altitude, 0 ft target elevation, and 0.0 ft/sec ejection velocity. Released from PMBR A/A 37B-3.

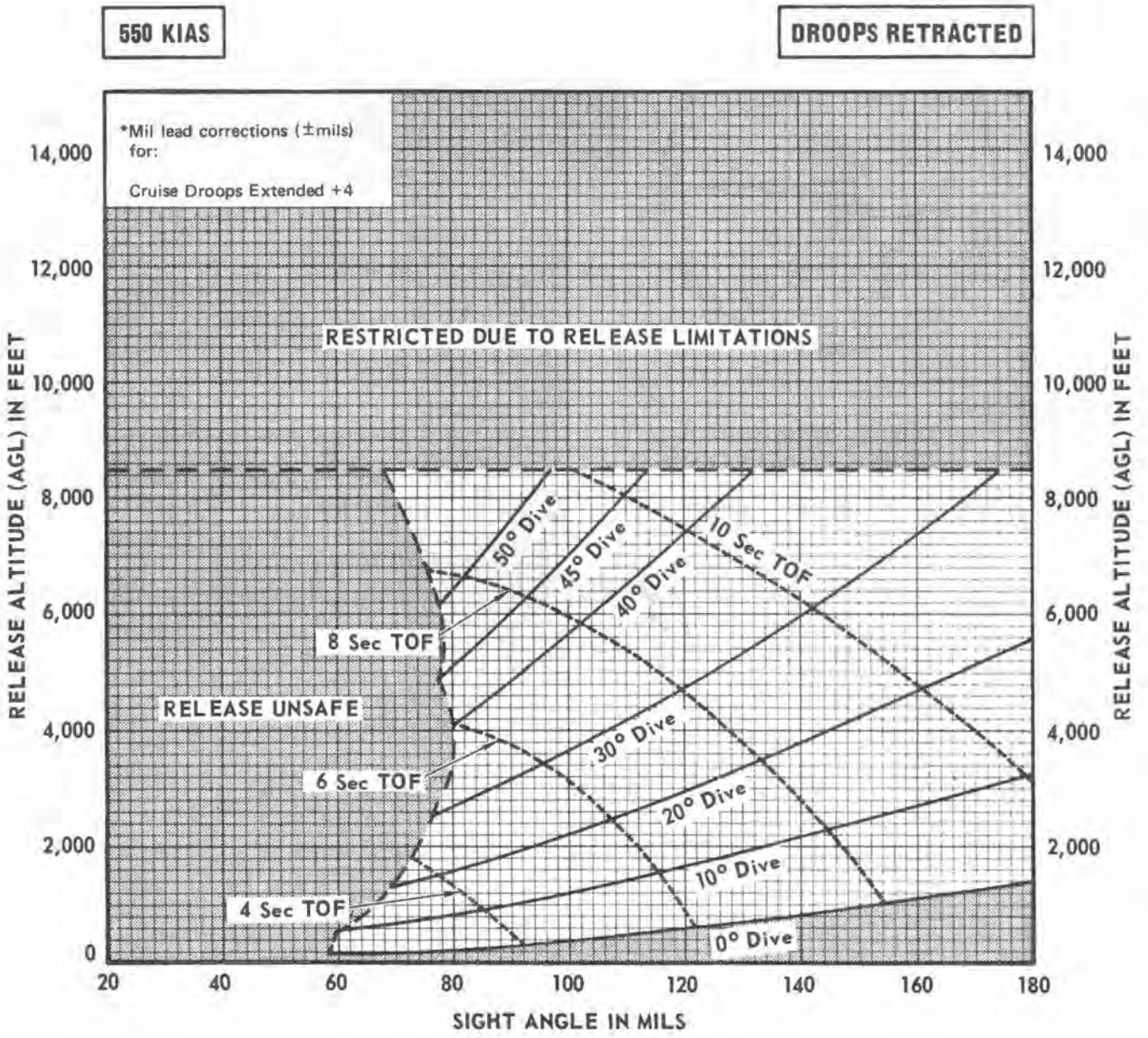
*For each 10°C increase (decrease) in temperature at release altitude, increase (decrease) the mil lead by 3 mils.

AZ-200(4)-3-69

Figure 2-91 (Sheet 4)

Mil Lead for Single Delivery

MK 89 MOD 0 PRACTICE BOMB



NOTE

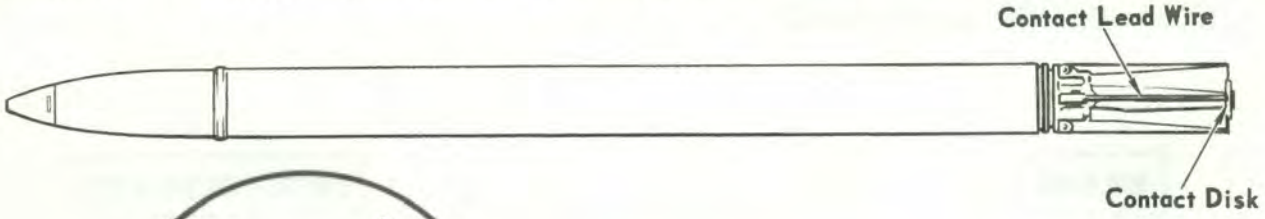
Sight angles are based on 27,000 lb aircraft gross weight, 0 ft burst altitude, 0 ft target elevation, and 0.0 ft/sec ejection velocity. Released from PMBR A/A 37B-3.

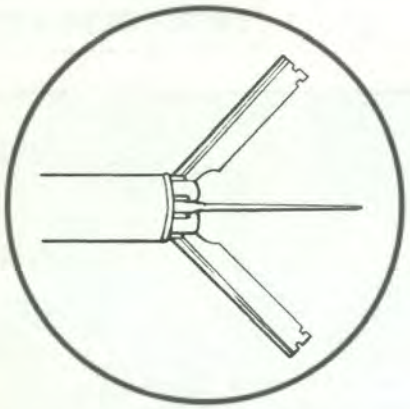
*For each 10°C increase (decrease) in temperature at release altitude, increase (decrease) the mil lead by 3 mils.

AZ-200(5)-3-69

Figure 2-91 (Sheet 5)

2.75-Inch Folding Fin Aircraft Rocket





PHYSICAL CHARACTERISTICS

Weight – 18.5 pounds
Length – 48 inches
Diameter – 2.75 inches

LAUNCHERS

LAU-3/A, LAU-32A/A, LAU-32B/A, LAU-56/A, LAU-60/A
Aero 6A; 6A-1; 6A-2, Aero 7D, LAU-61/A
LAU-68/A, LAU-69/A

DESCRIPTION

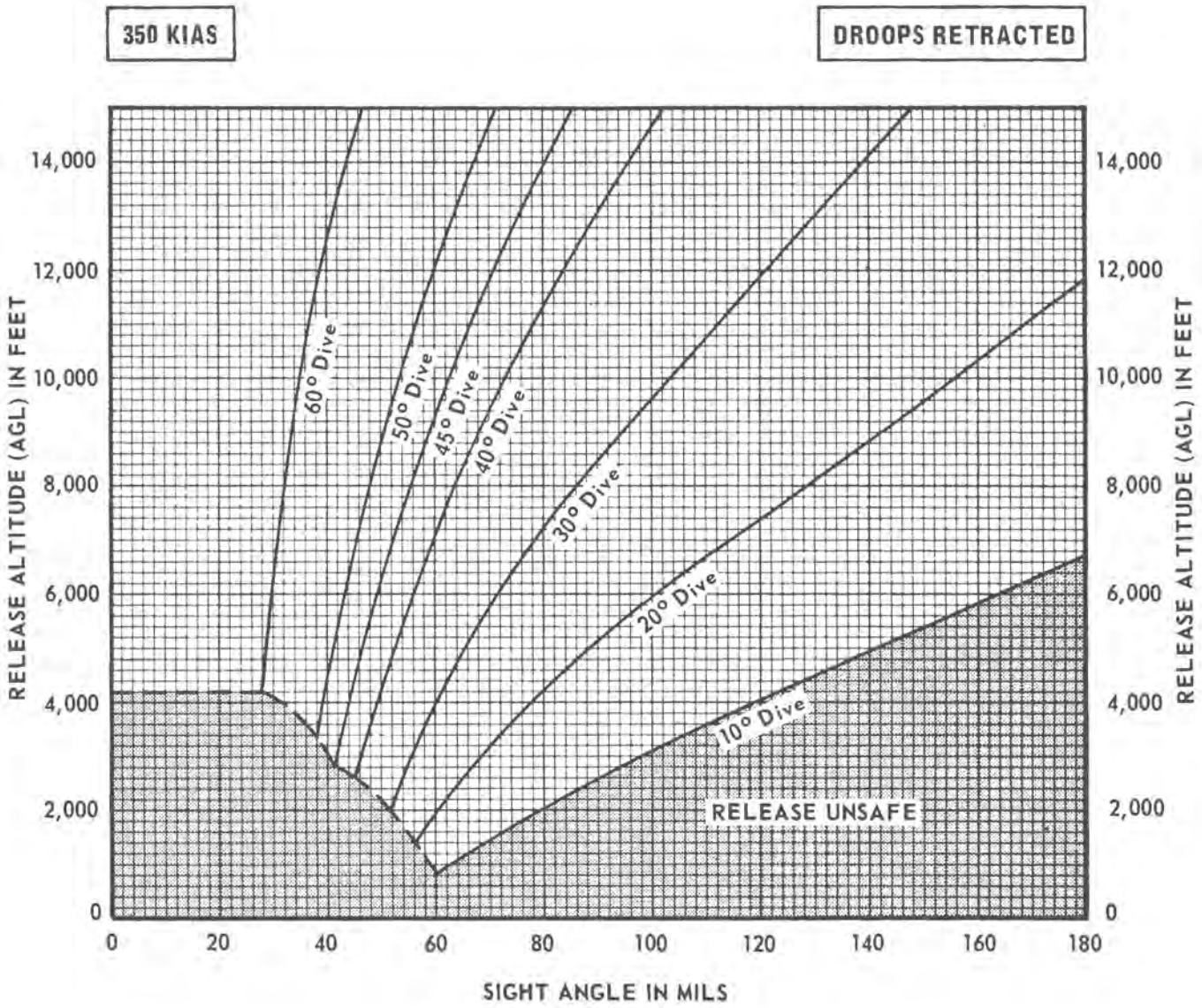
The 2.75-inch folding fin aircraft rocket is designed as air-to-ground armament for tactical aircraft. The rocket is adapted to use a high explosive head, a high explosive anti-tank head, or an inert head for practice. The rocket is ignited by electrical power transmitted when the stores release switch is depressed. The folded fins are opened by gas pressure as the rocket leaves the launcher.

AZ-108-3-69

Figure 2–92

Mil Lead for Single Delivery

2.75 INCH FFAR



NOTE

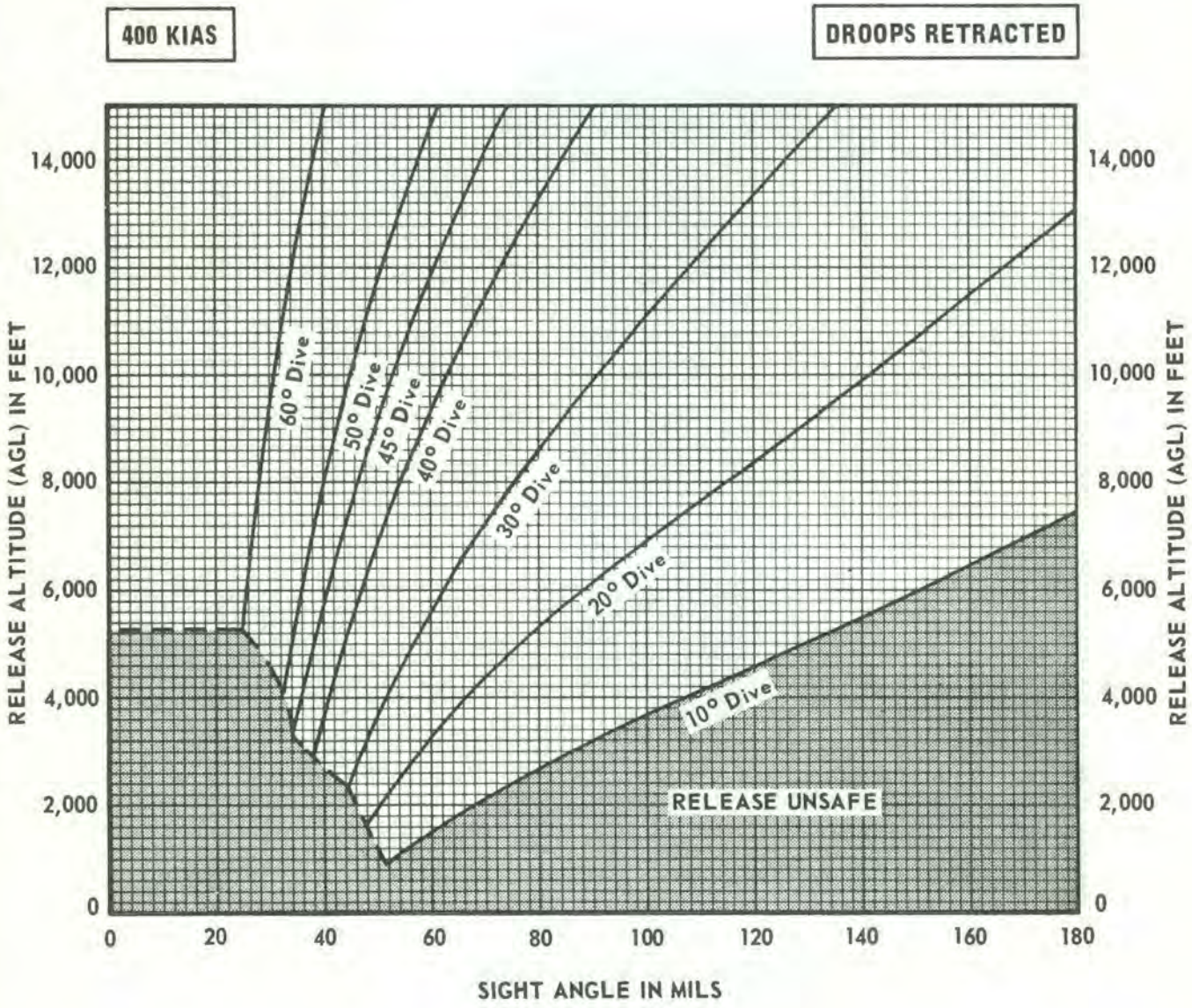
Sight angles are based on 27,000-lb aircraft gross weight, 0-ft burst altitude, and 0-ft target elevation.

AZ-236(1)-2-67

Figure 2-93 (Sheet 1)

Mil Lead for Single Delivery

2.75 INCH FFAR



NOTE

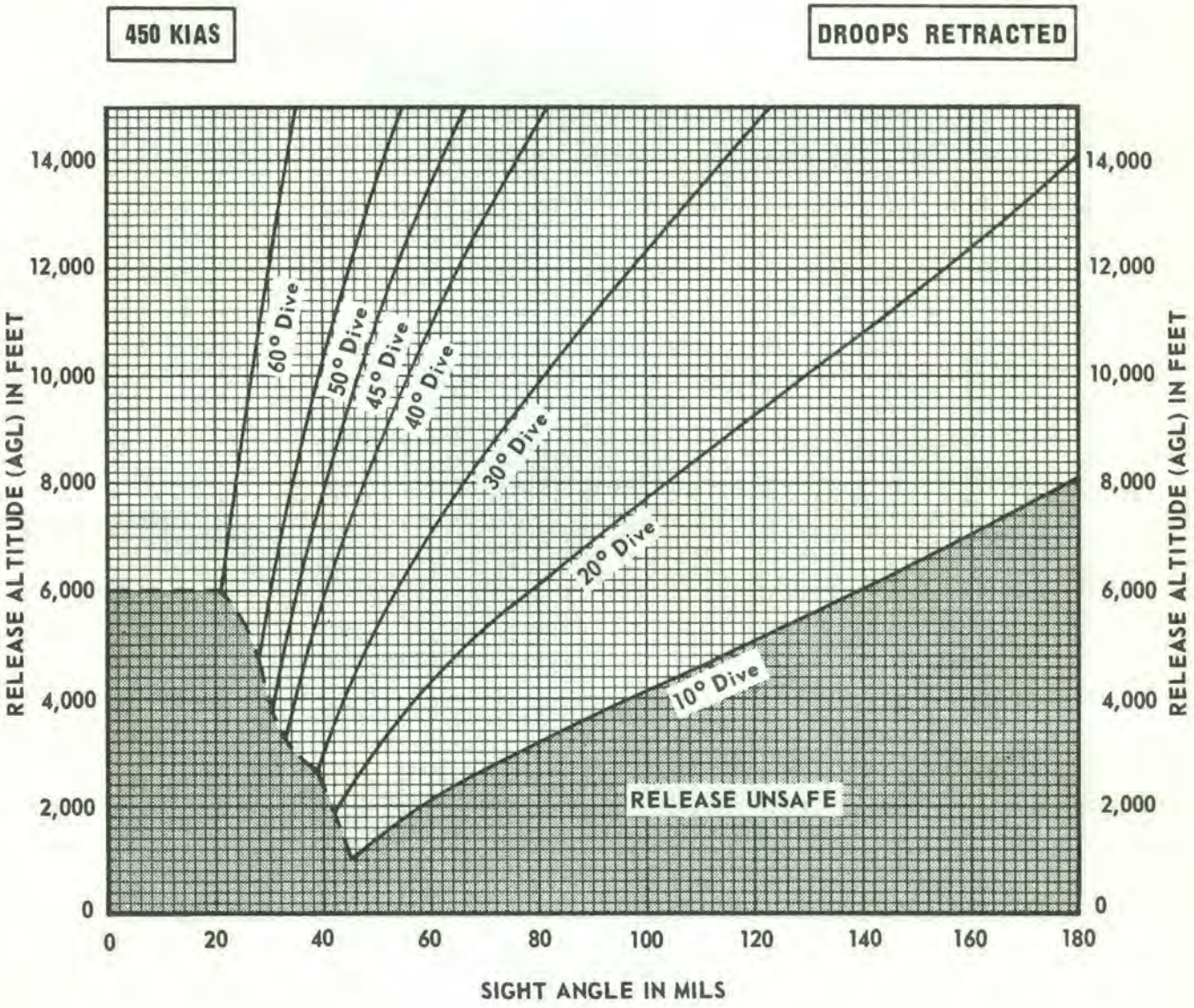
Sight angles are based on 27,000-lb aircraft gross weight, 0-ft burst altitude, and 0-ft target elevation.

AZ-236(2)-2-67

Figure 2-93 (Sheet 2)

Mil Lead for Single Delivery

2.75 INCH FFAR



NOTE

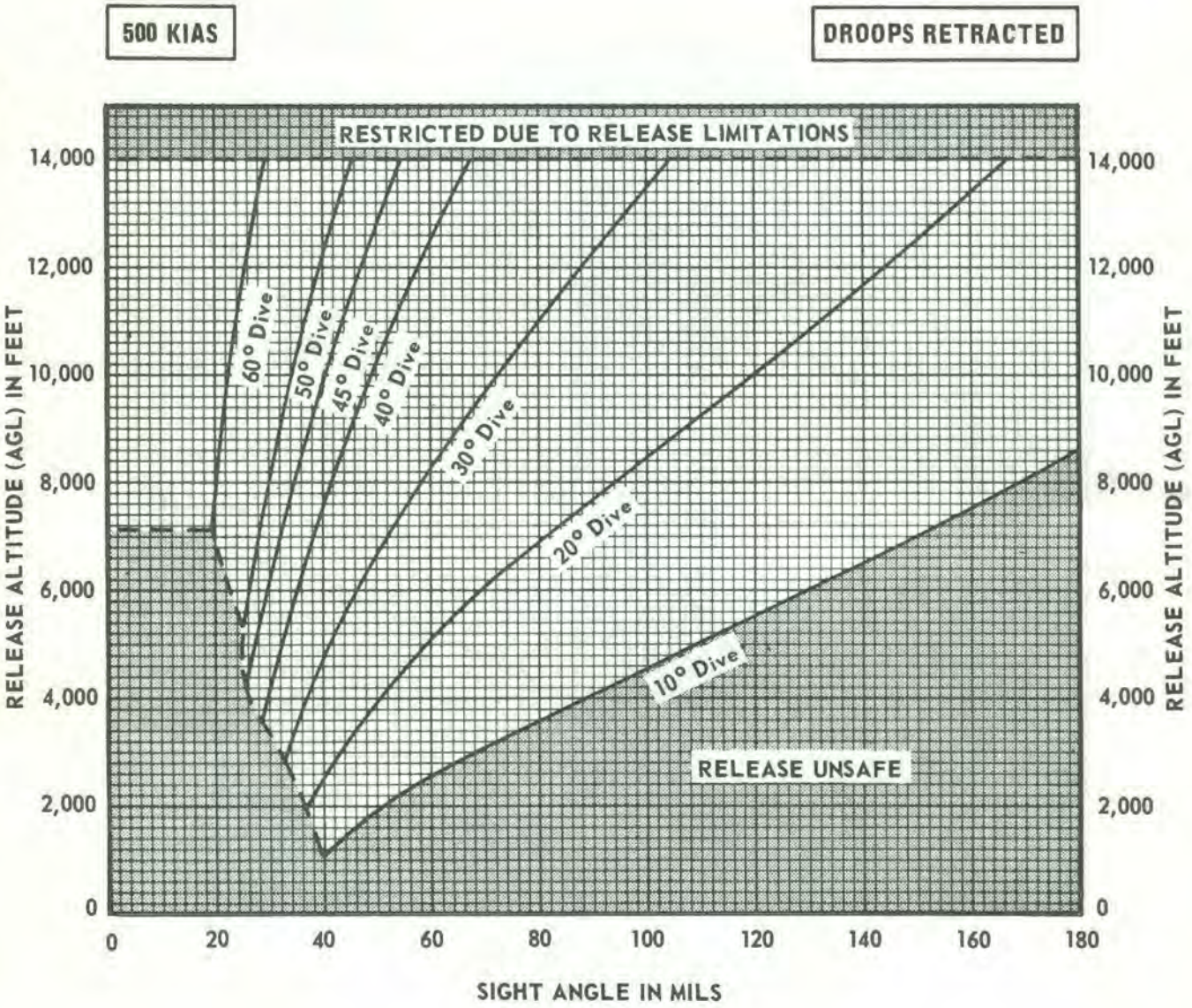
Sight angles are based on 27,000-lb aircraft gross weight, 0-ft burst altitude, and 0-ft target elevation.

AZ-236(3)-2-67

Figure 2-93 (Sheet 3)

Mil Lead for Single Delivery

2.75 INCH FFAR



NOTE

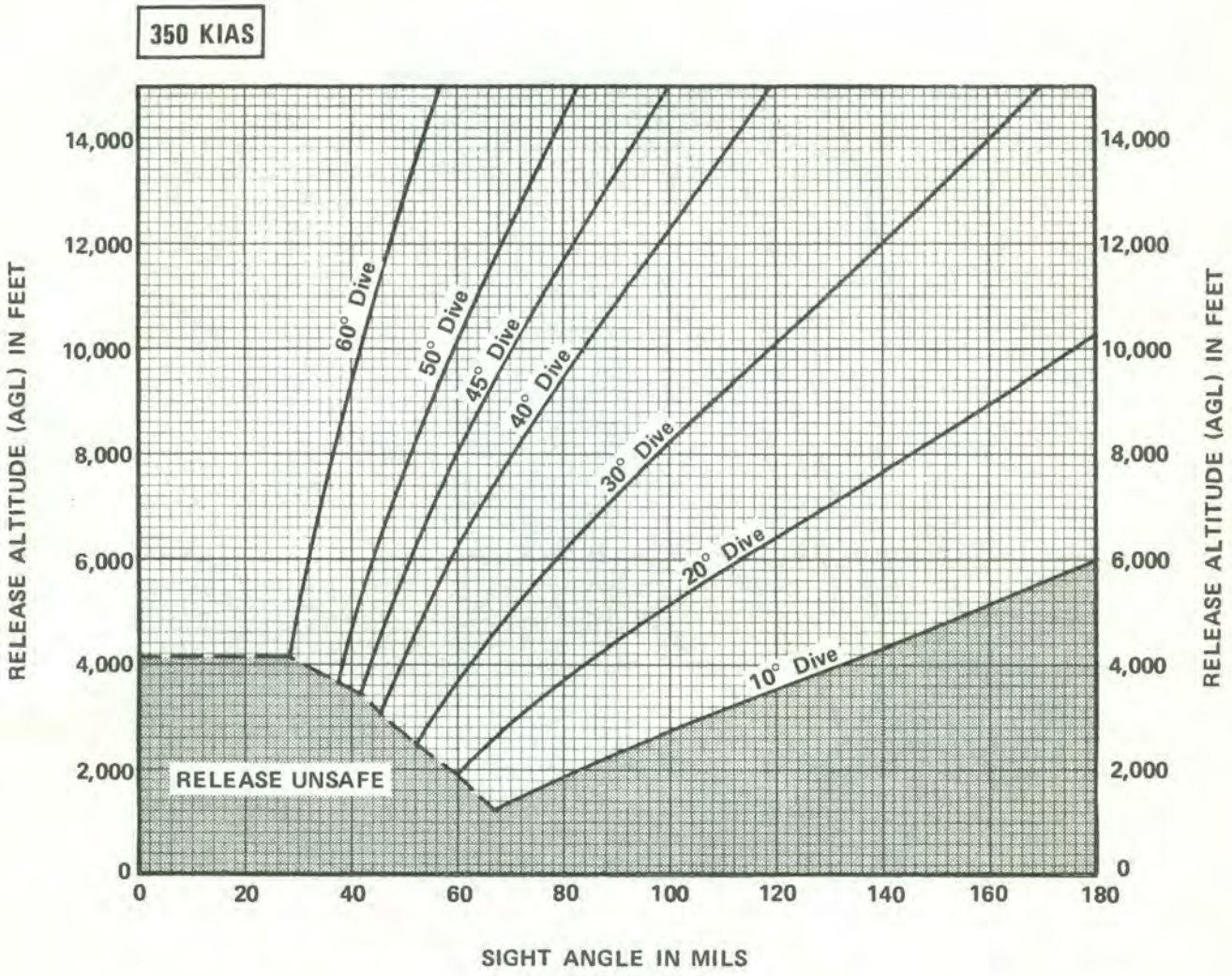
Sight angles are based on 27,000-lb aircraft gross weight, 0-ft burst altitude, and 0-ft target elevation.

AZ-236(4)-2-67

Figure 2-93 (Sheet 4)

Mil Lead for Single Delivery

2.75 INCH FFAR – M151 WARHEAD, MK 4 AND MODS MOTOR



NOTE

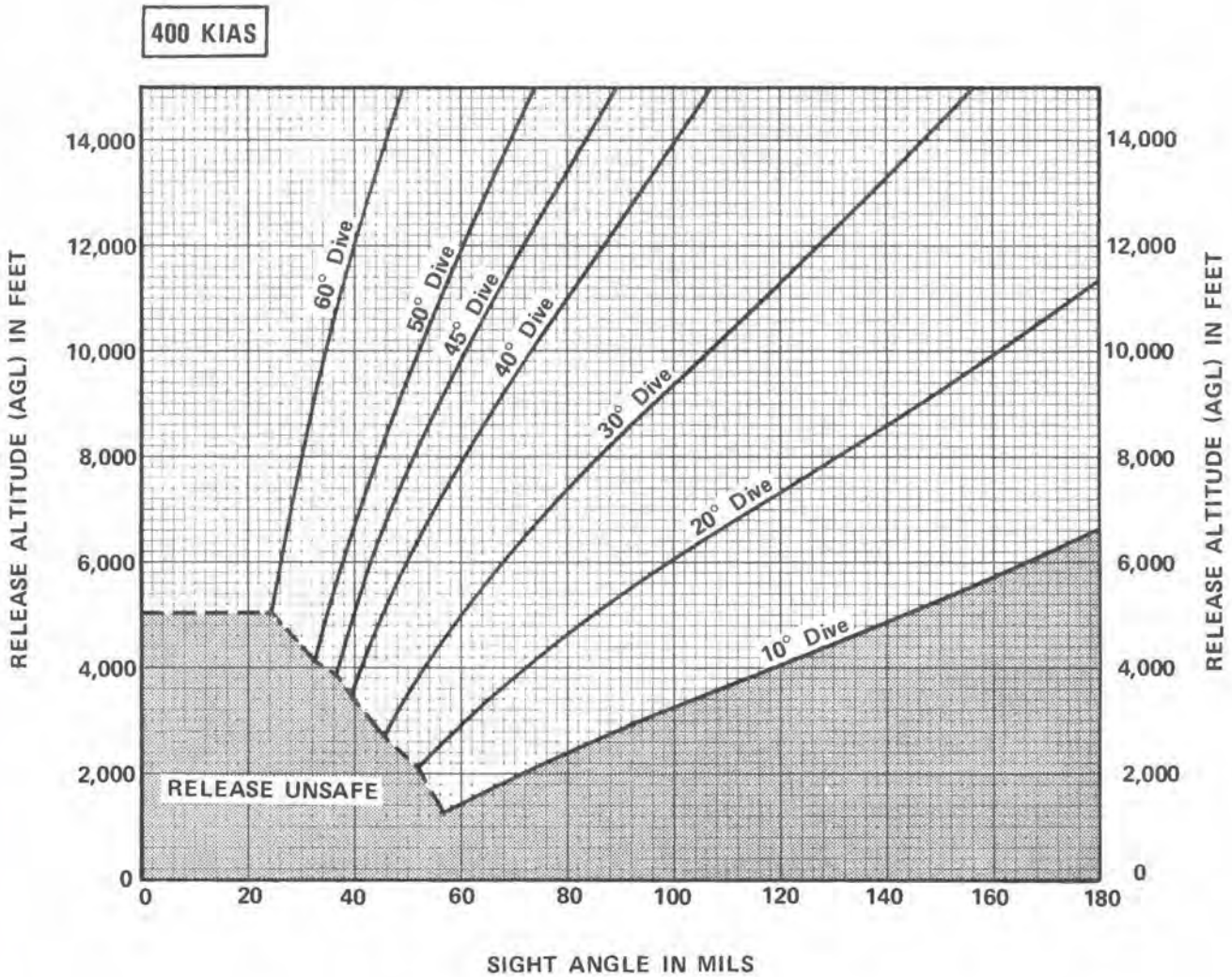
1. Sight angles are based on 27,000-pound aircraft gross weight, 0-foot burst altitude, and 0-foot target elevation.
2. Propellent temperature 70°F.

AZ-354(1)-03-70

Figure 2-93A (U) (Sheet 1)

Mil Lead for Single Delivery

2.75 INCH FFAR – M151 WARHEAD, MK 4 AND MODS MOTOR



NOTE

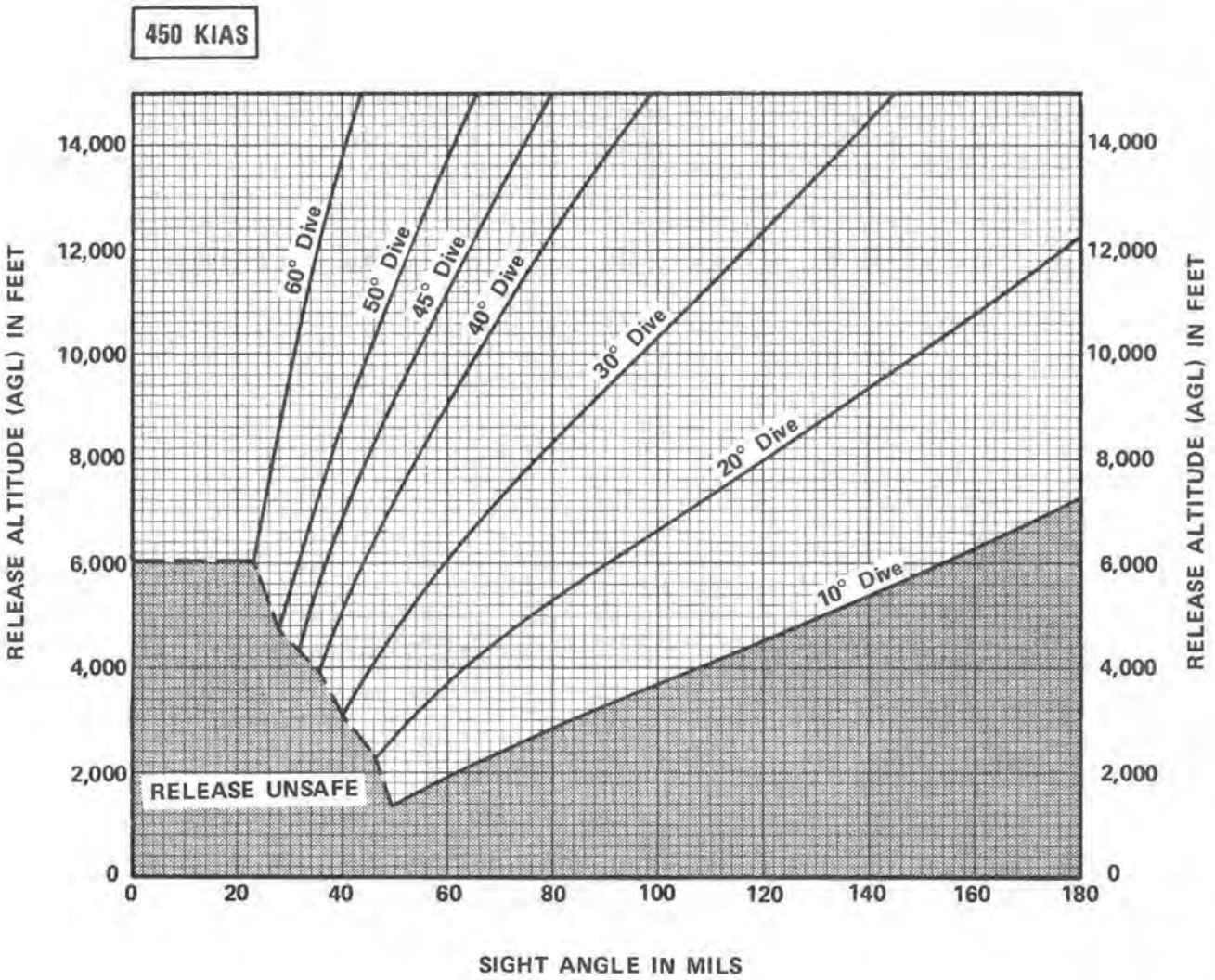
1. Sight angles are based on 27,000-pound aircraft gross weight, 0-foot burst altitude, and 0-foot target elevation.
2. Propellent temperature 70°F.

AZ-354(2)-03-70

Figure 2-93A (U) (Sheet 2)

Mil Lead for Single Delivery

2.75 INCH FFAR – M151 WARHEAD, MK 4 AND MODS MOTOR



NOTE

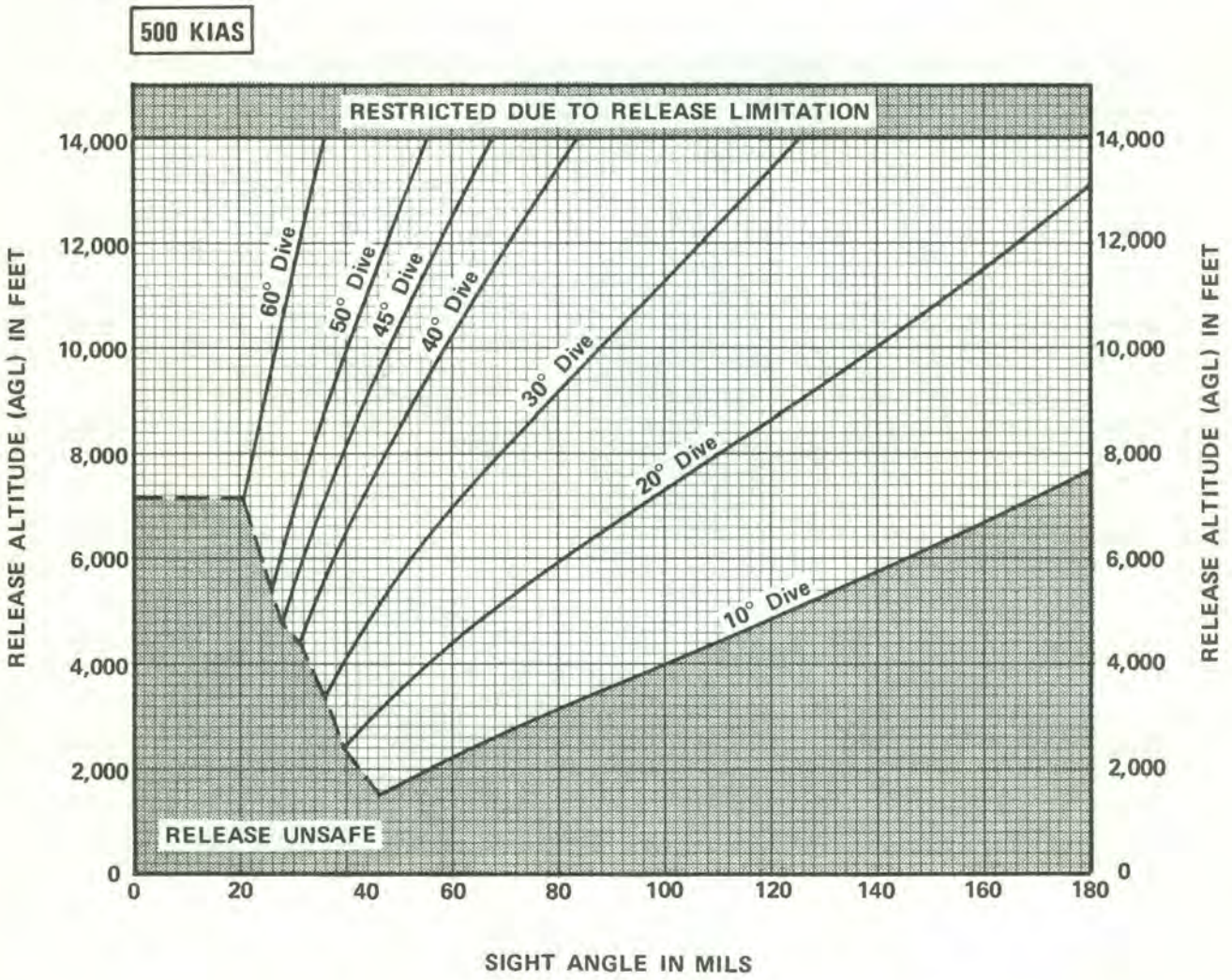
1. Sight angles are based on 27,000-pound aircraft gross weight, 0-foot burst altitude, and 0-foot target elevation.
2. Propellent temperature 70°F.

AZ-354(3)-03-70

Figure 2-93A (U) (Sheet 3)

Mil Lead for Single Delivery

2.75 INCH FFAR – M151 WARHEAD, MK 4 AND MODS MOTOR



NOTE

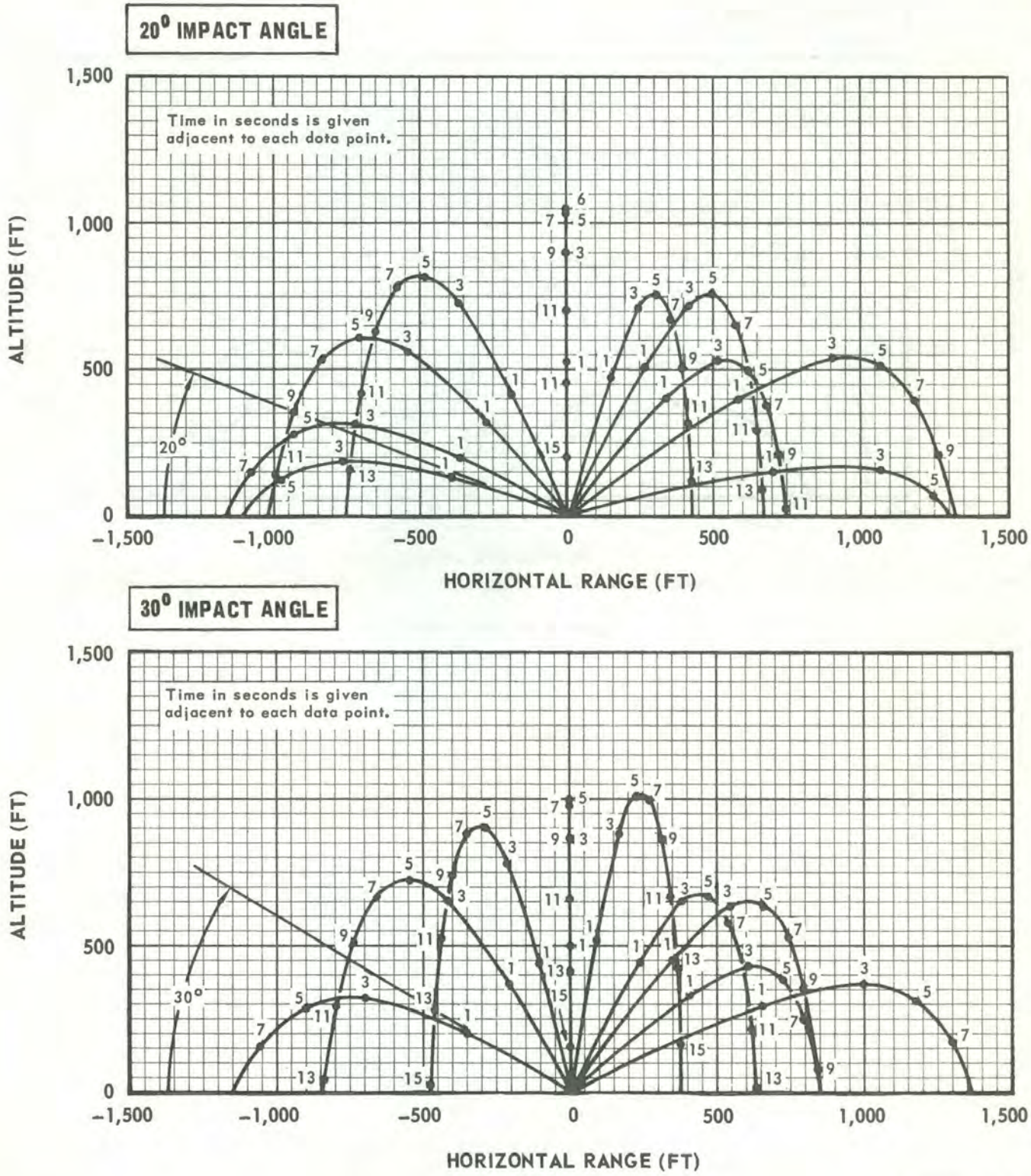
1. Sight angles are based on 27,000-pound aircraft gross weight, 0-foot burst altitude, and 0-foot target elevation.
2. Propellent temperature 70°F.

AZ-354(4)-03-70

Figure 2-93A (U) (Sheet 4)

Maximum Fragment Envelope

2.75-INCH FFAR – MK 1 MOD 1 WARHEAD



AZ−296(1)−5−68

Figure 2–94 (Sheet 1)

Maximum Fragment Envelope

2.75-INCH FFAR – MK 1 MOD 1 WARHEAD

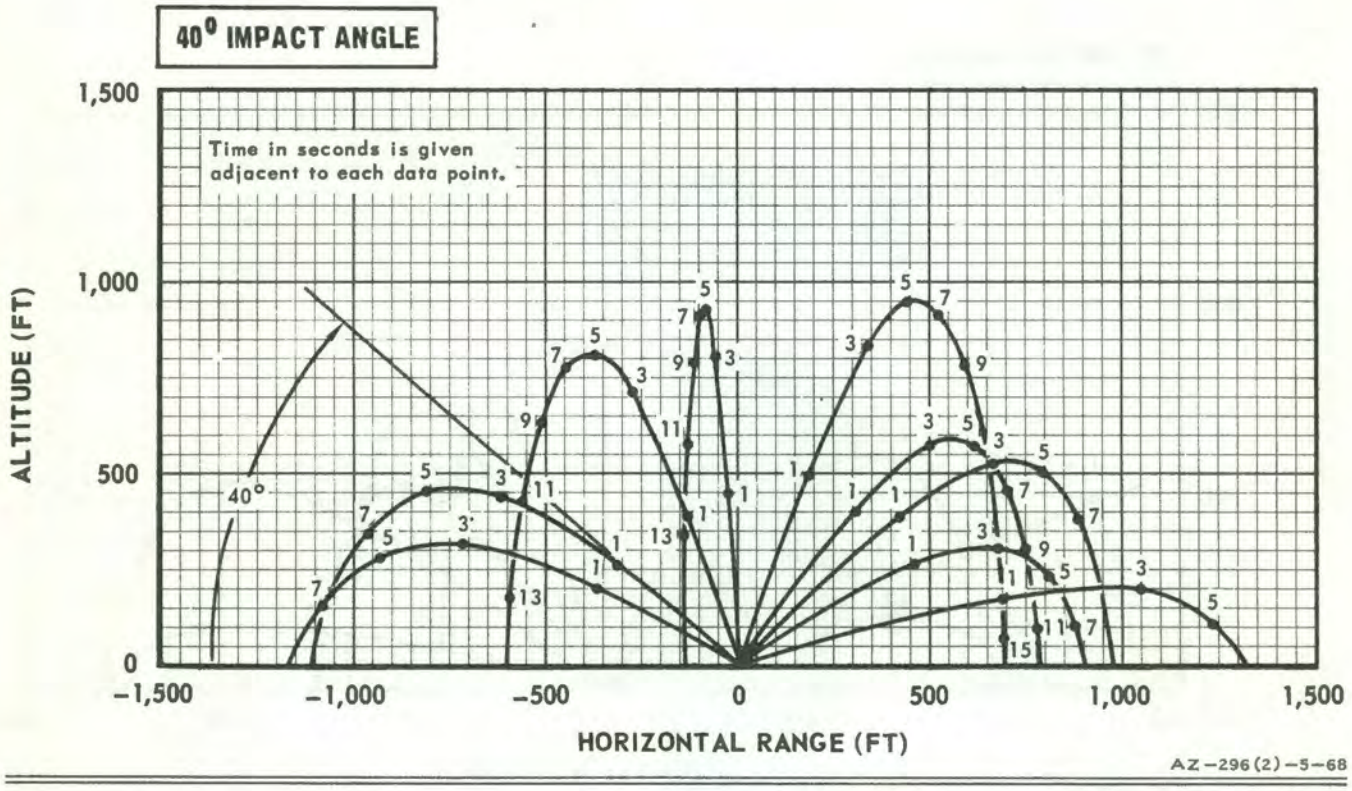


Figure 2–94 (Sheet 2)

2.75 INCH FFAR

DIVE ANGLE	MIL LEAD	ENTRY			RELEASE			CORRECTION PER 10 KT OF WIND -MILS		RELEASE ERROR SENSITIVITIES				
		KIAS	ALTITUDE FT AGL	APPROX RPM%	KTAS	ALTITUDE FT AGL	ALTIMETER LAG-FT	Range	Cross	FT/10KT KIAS	FT/100FT ALTITUDE	FT/DEG DIVE ANGLE	FT/MIL RANGE	FT/MIL DEFLECTION
10°	60	375–400	2,500	92–93	450	800	100	2	7	3	20	8	12	4
20°	52	400	5,000	94–96	500	2,000	200	3	8	5	10	11	15	6
30°	48	350	7,000	94–96	500	2,500	250	4	8	3	10	5	9.5	5
45°	60	250	12,000	86–88	450	4,500	0	6	8	2	9	4	8	6

NOTES

1. Error sensitivities are applied as follows:

   Airspeed – Fast impacts long
   Slow impacts short

   Altitude – High impacts short
   Low impacts long

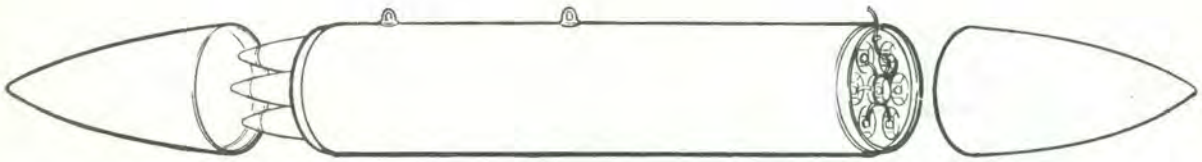
   Dive Angle – Steep impacts long
   Shallow impacts short

2. Mil leads are computed for the cruise droop extended.
3. 45° dive profile flown with speed brakes OUT.

AZ-247-2-67

Figure 2-94A

Aero 6A, 6A-1, 6A-2 Rocket Launchers



DESCRIPTION

The Aero 6A, 6A-1 and 6A-2 rocket launchers are expendable stores to ship, stow and fire seven 2.75 inch FFAR motors. The warheads are added during loading operation. Frangible fairings are used to reduce drag prior to firing the rockets. The rockets are ripple fired by intervalometer at a rate of 100 per second. A KMU-52A/A rocket launcher training aid can be installed to provide a single-fire capability

WING STATION LOADING CONFIGURATIONS

WING LOADING	EQUIPMENT-WEIGHT	
AERO 7A-1 SUSPENSION One Launcher Each Wing	2 Aero 6A 2 Aero 7A-1 2 Pylons	296 104 350
	Total One Wing Only	750 375
TER SUSPENSION Two Launchers Each Wing	4 Aero 6A 2 Aero 7A-1 2 Pylons	592 104 350
	Total One Wing Only	1046 523

CAUTION

Jettison this launcher when carrying live or inert warheads whether or not a firing attempt has been made when a carrier or field arrestment is anticipated.

JETTISONING PROCEDURES

See JETTISONING this section.

PHYSICAL CHARACTERISTICS

Weight (Loaded)	–	148 pounds
Length	–	75.1 inches
Diameter	–	9.75 inches
Suspension lugs	–	14 inches apart

FIRING PROCEDURES

1. **Master Arm Sw – ON**
2. **Armament Sel Sw – Wing L or R**
3. **Stores Release Sw – DEPRESS**

NOTE

When the rocket launcher is carried on the TER the pylon MER/TER switch must be placed in the RKT position to avoid jettisoning the launcher instead of firing the rockets.

To fire rockets from both wings simultaneously, the Triple-Multiple Rack Fire Mode switch in each pylon must be set to the DUAL position. To fire two launchers on the same wing, the stores release switch must be depressed twice.

To step the TER stepping switch past an empty station, it is necessary to have the hooks at that station open or the stores release switch must be depressed and released once for each empty station between launchers.

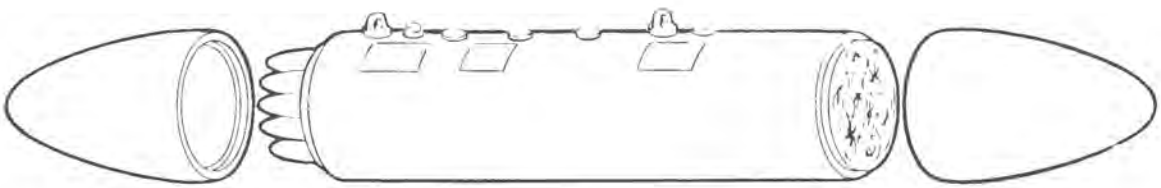
REFERENCES

1. Restrictions – See Figure 2-2
2. Rocket Launcher Loading, Arming and Preflight Inspection – NAVAIR 01-45HH-75

AZ–110–03–69

Figure 2–95

Aero 7D Rocket Launcher



DESCRIPTION

The AERO 7D is an expendable launcher used for shipment, storage and launching nineteen 2.75 FFAR motors. Warheads are added during loading operations. Two frangible fairings are used to reduce drag prior to firing the rockets. The rockets are ripple fired at a rate of 100 per second. A SWU-7/A37 rocket launcher training aid can be installed to provide a mode for firing eighteen rockets in nine launchings of two rockets each.

PHYSICAL CHARACTERISTICS

Weight (Loaded)	431 pounds
Length	98.6 inches
Diameter	15.7 inches
Suspension lugs	14 or 30 inches

WING STATION LOADING CONFIGURATIONS

WING LOADING	EQUIPMENT-WEIGHT	
AERO 7A-1 SUSPENSION One Launcher Each Wing	2 Aero 7D 2 Aero 7A-1 2 Pylons	862 104 350
	Total One Wing Only	1316 658
TER SUSPENSION Two Launchers Each Wing	4 Aero 7D 2 Aero 7A-1 2 Pylons	1724 104 350
	Total One Wing Only	2178 1089

CAUTION

Jettison this launcher when carrying live or inert warheads whether or not a firing attempt has been made when a carrier or field arrestment is anticipated.

JETTISONING PROCEDURES

See JETTISONING this section

FIRING PROCEDURES

1. Master Arm Sw – ON
2. Armament Sel Sw – Wing L or R
3. Stores Release Sw – DEPRESS

NOTE

When the rocket launcher is carried on the TER the pylon MER/TER switch must be placed in the RKT position to avoid jettisoning the launcher instead of firing the rockets.

To fire rockets from both wings simultaneously, the Triple-Multiple Rack Fire Mode switch in each pylon must be set to the DUAL position. To fire two launchers on the same wing, the stores release switch must be depressed twice.

To step the TER stepping switch past an empty station, it is necessary to have the hooks at that station open or the stores release switch must be depressed and released once for each empty station between launchers.

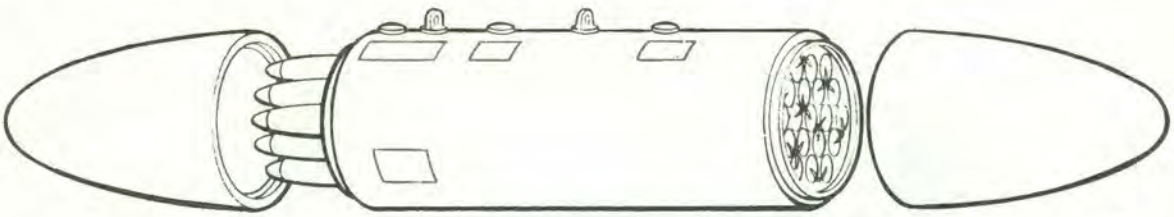
REFERENCES

1. Restrictions – See Figure 2-2
2. Rocket Launcher Loading Arming and Preflight Inspections – NAVAIR 01-45HH-75

AZ-111-01-69

Figure 2–96

LAU-3A/A Rocket Launcher



PHYSICAL CHARACTERISTICS

Weight (Empty) – 81 pounds
(Loaded) – 417 pounds
Length – 94.5 inches
Diameter – 15.75 inches
Suspension lugs – 14 inches

DESCRIPTION

The LAU 3A/A rocket launcher contains 19 paper tubes clustered and bonded together then wrapped with aluminum outer skin. Detent devices within the tubes retain the 2.75-inch FFAR. Fairings cover the ends to streamline the launcher prior to firing the rockets. These fairings are shattered by the rockets which are ripple fired at a rate of 100 rounds per second. When a SWU-31/A switch is used, a selectable option exists for single or ripple fire.

WING STATION LOADING CONFIGURATION		
WING LOADING	**EQUIPMENT-WEIGHT**	
AERO 7A-1 SUSPENSION One Launcher Each Wing	2 LAU 3A/A 2 Aero 7A-1 2 Pylons Total One Wing Only	834 104 350 1288 644
TER SUSPENSION Two Launchers Each Wing	4 LAU 3A/A 2 Aero 7A-1 2 Pylons 2 TER Total One Wing Only	1668 104 350 210 2332 1166

FIRING PROCEDURES

1. Master Arm Sw – ON
2. Armament Sel Sw – Wing L or R
3. Stores Release Sw – DEPRESS

NOTE

When the rocket launcher is carried on the TER the pylon MER/TER switch must be placed in the RKT position to avoid jettisoning the launcher instead of firing the rockets.

To fire rockets from both wings simultaneously the Triple-Multiple Rack Fire Mode switch in each pylon must be set to the DUAL position. To fire two launchers on the same wing the stores release switch must be depressed twice.

To step the TER stepping switch past an empty station it is necessary to have the hooks at that station open or the stores release switch must be depressed and released once for each empty station between launchers.

CAUTION

Jettison this launcher when carrying live or inert warheads whether or not a firing attempt has been made when a carrier or field arrestment is anticipated.

REFERENCES

1. Restrictions – See Figure 2-2
2. Rocket Launcher Arming – NAVAIR 01-45HH-75
3. Preflight Inspection – NAVAIR 01-45HH-75
4. Rocket Launcher Loading – NAVAIR 01-45HH-75

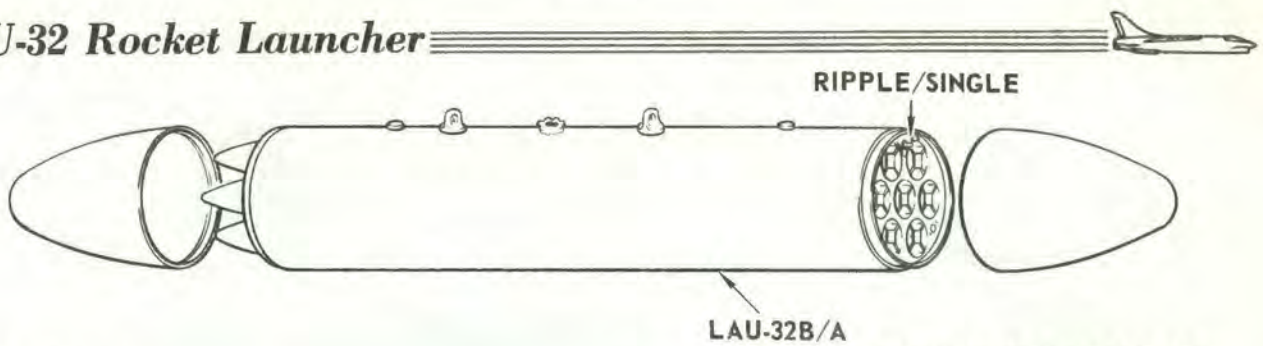
JETTISONING PROCEDURES

See JETTISONING this section.

AZ-112-03-69

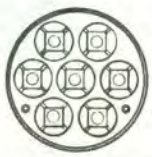
Figure 2-97

LAU-32 Rocket Launcher



DESCRIPTION

The LAU 32A/A and the LAU 32B/A rocket launchers carry seven 2.75-inch folding fin aircraft rockets. They are equipped with frangible fairings at both ends. The fairings shatter when the rockets are launched. The LAU 32A/A launcher has paper launching tubes, and is intended to be jettisoned after use. Rockets are ripple fired unless a SWU-31/A switch is used with the LAU-32A/A. When the SWU-31/A switch is used, a selectable option exists for single or ripple fire. The LAU 32B/A launcher has aluminum launching tubes, an intervalometer which is adjustable and reusable and a selectable option of single or ripple fire. Selection of single or ripple must be made prior to installing the aft fairing.



PHYSICAL CHARACTERISTICS

Weight (Empty)	– 47 pounds
(Loaded)	– 168 pounds
Length	– 67.1 inches
Diameter	– 9.8 inches
Suspension lugs	– 14 inches apart

WING STATION LOADING CONFIGURATIONS

WING LOADING	EQUIPMENT-WEIGHT	
AERO 7A-1 SUSPENSION One Launcher Each Wing	2 LAU 32A/A 2 Aero 7A-1 2 Pylons	336 104 350
	Total One Wing Only	790 395
TER SUSPENSION Two Launchers Each Wing	4 LAU 32A/A 2 Aero 7A-1 2 Pylons 2 TER	672 104 350 210
	Total One Wing Only	1336 668

FIRING PROCEDURES

1. Master Arm Sw – ON
2. Armament Sel Sw – Wing L or R
3. Stores Release Sw – DEPRESS

NOTE

When the rocket launcher is carried on the TER, the pylon MER/TER switch must be placed in the RKT position to avoid jettisoning the launcher instead of firing the rockets.

To fire rockets from both wings simultaneously the Triple-Multiple Rack Fire Mode switch in each pylon must be set to the DUAL position.

To fire two launchers on the same wing the stores release switch must be depressed twice.

To step the TER stepping switch past an empty station it is necessary to have the hooks at that station open or the stores release switch must be depressed and released once for each empty station between launchers.

REFERENCES

1. Restrictions – See Figure 2–2.
2. Rocket Launcher Loading, Arming and Preflight Inspection – NAVAIR 01-45HH-75.

CAUTION

Jettison this launcher when carrying live or inert warheads whether or not a firing attempt has been made when a carrier or field arrestment is anticipated.

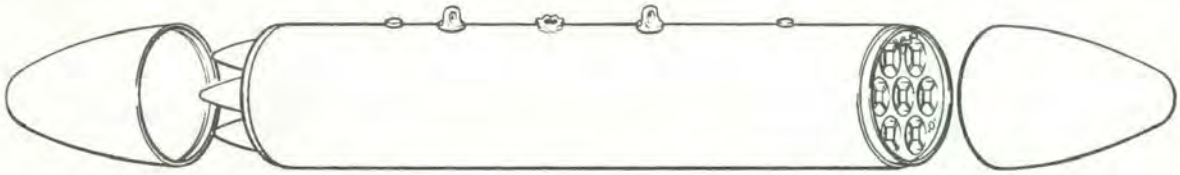
JETTISONING PROCEDURES

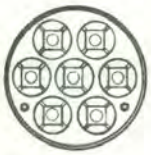
See JETTISONING , this section.

AZ-114-03-69

Figure 2–98

LAU-56/A Rocket Launcher





PHYSICAL CHARACTERISTICS

Weight	– 168 pounds
Length	– 67.1 inches
Diameter	– 9.8 inches
Suspension lugs	– 14 and 30 inches apart, single lug centered

DESCRIPTION

The LAU 56/A carries and fires seven 2.75-inch FFAR. The launcher is similar in size and shape to the LAU-32 launcher. The launcher has a selectable SINGLE or RIPPLE fire option.

WING STATION LOADING CONFIGURATION

WING LOADING	EQUIPMENT-WEIGHT
AERO 7A SUSPENSION One Launcher Each Wing 	2 LAU 56/A 336 2 Aero 7A-1 104 2 Pylons 350 Total 790 One Wing Only 395
TER SUSPENSION Two Launchers Each Wing 	4 LAU 56/A 672 2 Aero 7A-1 104 2 Pylons 350 2 TER 210 Total 1336 One Wing Only 668

FIRING PROCEDURES

1. Master Arm Sw – ON
2. Armament Sel Sw – Wing L or R
3. Stores Release Sw – DEPRESS

NOTE

When the rocket launcher is carried on the TER the pylon MER/TER switch must be set to the RKT position to prevent jettisoning the launcher instead of firing the rockets.

To fire rockets from both wings simultaneously, the Triple-Multiple Rack Fire Mode switch in each pylon must be set to the DUAL position.

To fire two launchers on the same wing the stores release switch must be depressed twice.

To step the TER stepping switch past an empty station it is necessary to have the hooks at that station open, or the stores release switch must be depressed and released once for each empty station between launchers.

CAUTION

Jettison this launcher when carrying live or inert warheads whether or not a firing attempt has been made when a carrier or field arrestment is anticiputed.

REFERENCES

1. Restrictions – See Figure 2-1
2. Rocket Launcher Arming – NAVAIR 01-45HH-75
3. Preflight Inspection – NAVAIR 01-45HH-75
4. Rocket Launcher Loading – NAVAIR 01-45HH-75

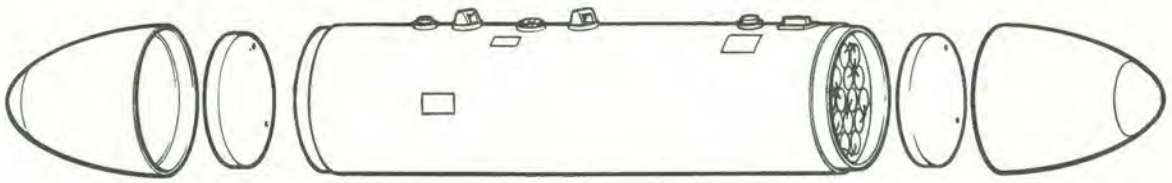
JETTISONING PROCEDURES

See JETTISONING, this section.

AZ–131–03–69

Figure 2–99

LAU-60/A Rocket Launcher



DESCRIPTION

The center section of the LAU-60/A rocket launcher contains the suspension, electrical system, fire control system and a cluster of 19 fiber rocket tubes. A detent on each tube retains and ignites the 2.75-inch folding fin aircraft rockets which are fired in pairs. Forward and aft fairings are attached to the center section by a locking band and are shattered by the rockets which are ripple fired at a rate of 100 per second.

PHYSICAL CHARACTERISTICS

Weight	(Empty)	– 79.0 pounds
	(Loaded)	– 473.2 pounds
Length		– 86.5 inches
Diameter		– 15.5 inches
Suspension lugs		– 14.0 inches and center

WING STATION LOADING CONFIGURATION

WING LOADING	EQUIPMENT-WEIGHT	
AERO 7A-1 SUSPENSION One Launcher Each Wing	2 LAU-60/A 2 Aero 7A-1 2 Pylons	946 104 350
	Total One Wing Only	1400 700
TER SUSPENSION Two Launchers Each Wing	4 LAU-60/A 2 Aero 7A-1 2 Pylons 2 TER	1893 104 350 210
	Total One Wing Only	2557 1278

FIRING PROCEDURES

1. Master Arm Sw – ON
2. Armament Sel Sw – Wing L or R
3. Stores Release Sw – DEPRESS

NOTE

When the rocket launcher is carried on the TER, the pylon MER/TER switch must be placed in the RKT position to avoid jettisoning the launcher instead of firing the rockets.

To fire rockets from both wings simultaneously, the Triple-Multiple Rack Fire Mode switch in each pylon must be set to the DUAL position. To fire two launchers on the same wing the stores release switch must be depressed twice.

To step the TER stepping switch past an empty station, it is necessary to have the hooks at that station open or the stores release switch must be depressed and released once for each empty station between launchers.

REFERENCES

1. Restrictions – See Figure 2-2
2. Rocket Launcher Arming – NAVAIR 01-45HH-75
3. Preflight Inspection – NAVAIR 01-45HH-75
4. Rocket Launcher Loading – NAVAIR 01-45HH-75

CAUTION

Jettison this launcher when carrying live or inert warheads whether or not a firing attempt has been made when a carrier or field arrestment is anticipated.

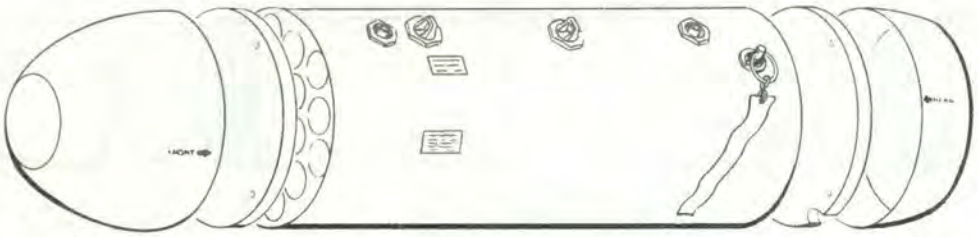
JETTISONING PROCEDURES

See JETTISONING this section.

AZ-265-03-69

Figure 2-100

LAU-61/A and LAU 69/A Rocket Launchers



PHYSICAL CHARACTERISTICS

Weight	(Empty)	– 98.0 pounds
	(Loaded)	– 506.5 pounds
Length		– 83.6 inches
Diameter		– 15.7 inches
Suspension lugs		– 14 inches

DESCRIPTION

The LAU-61/A and LAU-60/A are dual-purpose weapons designed for either air-to-air or air-to-surface use. These launchers carry and fire nineteen (19) 2.75 folding fin aircraft rockets. Each has a selective single or ripple fire grounded-type intervalometer, rf barriers and safety shorting pins. In the ripple mode two rockets are fired simultaneously with an elapsed time of 17–23 milliseconds between firings. A single rocket is discharged on the last firing. The nineteen rocket tubes of the LAU-61/A are aluminum. LAU-69/A tubes are fiber. LAU-61/A is reusable and the LAU-69/A is expendable. Initial rocket firing shatters the forward frangible fairing. The aft aluminum fairing is designed to remain intact and direct debris away from the aircraft.

WING STATION LOADING CONFIGURATION

WING LOADING	EQUIPMENT-WEIGHT	
AERO 7A-1 SUSPENSION One Launcher Each Wing	2 LAU 69/A 2 Aero 7A-1 2 Pylons	1013 104 350
	Total One Wing Only	1467 734
TER SUSPENSION Two Launchers Each Wing	4 LAU 69/A 2 Aero 7A-1 2 Pylons 2 TER	2026 104 350 210
	Total One Wing Only	2690 1345

FIRING PROCEDURES

1. Master Arm Sw – ON
2. Armament Sel Sw – Wing L or R
3. Stores Release Sw – DEPRESS

NOTE

When the rocket launcher is carried on the TER, the pylon MER/TER switch must be placed in the RKT position to avoid jettisoning the launcher instead of firing rockets.

To fire rockets from both wings simultaneously, the Triple-Multiple Rack Fire Mode switch in each pylon must be set to the DUAL position. To fire two launchers on the same wing, the stores release switch must be depressed twice.

To step the TER stepping switch past an empty station, it is necessary to have the hooks at that station open or the stores release switch must be depressed and released once for each empty station between launchers.

Forward RF barrier not required on LAU-61/A.

CAUTION

Jettison this launcher when carrying live or inert warheads whether or not a firing attempt has been made when a carrier or field arrestment is anticipated.

JETTISONING PROCEDURES

See JETTISONING this section.

REFERENCES

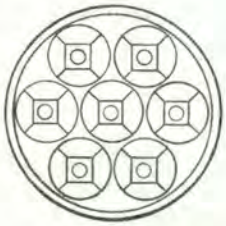
1. Restrictions – See Figure 2-2.
2. Rocket Launcher Arming – NAVAIR 01-45HH-75
3. Preflight Inspection – NAVAIR 01-45HH-75
4. Rocket Launcher Loading – NAVAIR 01-45HH-75

AZ-271-03-69

Figure 2-101

LAU-68/A Rocket Launcher





PHYSICAL CHARACTERISTICS

Weight	(Empty)	– 67.0 pounds
	(Loaded)	– 217.5 pounds
Length		– 70.9 inches
Diameter		– 9.8 inches
Suspension lugs		– 14 inches apart

DESCRIPTION

The LAU-68/A is a reusable launcher designed as a dual-purpose weapon for either air-to-air or air-to-surface use. It carries and fires seven (7) 2.75 folding fin aircraft rockets and incorporates a selective single or ripple fire grounded-type intervalometer, aft rf barrier and a safety shorting pin. Initial rocket firing shatters the forward frangible fairing. The aft aluminum fairing is designed to remain intact and direct debris away from the aircraft.

WING STATION LOADING CONFIGURATIONS

WING LOADING	EQUIPMENT-WEIGHT	
AERO 7A-1 SUSPENSION One Launcher Each Wing	2 LAU 68/A 2 Aero 7A-1 2 Pylons	435 104 350
	Total One Wing Only	889 445
TER SUSPENSION Two Launchers Each Wing	4 LAU 68/A 2 Aero 7A-1 2 Pylons 2 TER	870 104 350 210
	Total One Wing Only	1534 767

FIRING PROCEDURES

1. Master Arm Sw – ON
2. Armament Sel Sw – Wing L or R
3. Stores Release Sw – DEPRESS

NOTE

When the rocket launcher is carried on the TER, the pylon MER/TER switch must be placed in the RKT position to avoid jettisoning the launcher instead of firing the rockets.

To fire rockets from both wings simultaneously, the Triple-Multiple Rack Fire Mode switch in each pylon must be set to the DUAL position.

To fire two launchers on the same wing, the stores release switch must be depressed twice.

To step the TER stepping switch past an empty station, it is necessary to have the hooks at that station open or the stores release switch must be depressed and released once for each empty station between launchers.

CAUTION

Jettison this launcher when carrying live or inert warheads whether or not a firing attempt has been made when a carrier or field arrestment is anticipated.

JETTISONING PROCEDURES

See JETTISONING this section.

REFERENCES

1. Restrictions – See Figure 2-2
2. Rocket Launcher Loading, Arming and Preflight Inspection – NAVAIR 01-45HH-75

AZ-272-03-69

Figure 2–102

5.0-Inch Folding Fin Aircraft Rocket (Zuni)



PHYSICAL CHARACTERISTICS
Weight – 107 pounds
Length – 95 to 110 inches
Diameter – 5.0 inches

LAUNCHERS
LAU-10/A, -10A/A, LAU-33A/A
LAU-35A/A

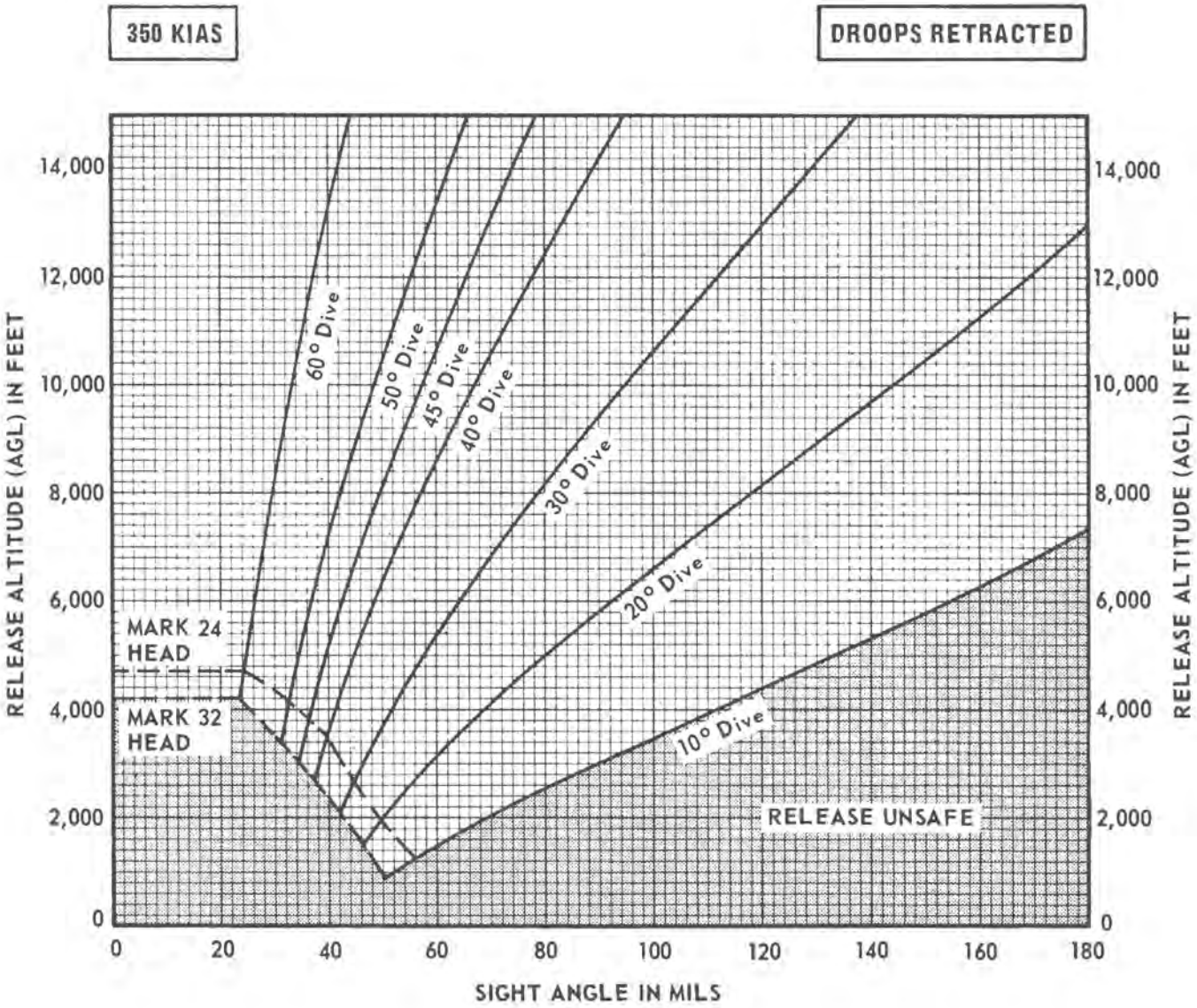
DESCRIPTION
The 5-inch Zuni rocket is a Navy-developed high explosive munition which offers several advantages over other air-to-ground rockets. The peak velocity of the Zuni rocket is very fast, exceeding the velocity of a 50-caliber machine gun round. This high velocity results in an extremely short time of flight. Gravity and wind effects are thus very small resulting in a high degree of accuracy. The high velocity also produces considerable target damage due to shock effect. The rocket consists of a motor, a warhead and a fuze. At the aft end of the motor are four blast-actuated fins which extend when the rocket leaves the launcher.

AZ-109-5-68

Figure 2–103

Mil Lead for Single Delivery

5.0 INCH FFAR (ZUNI)



NOTE

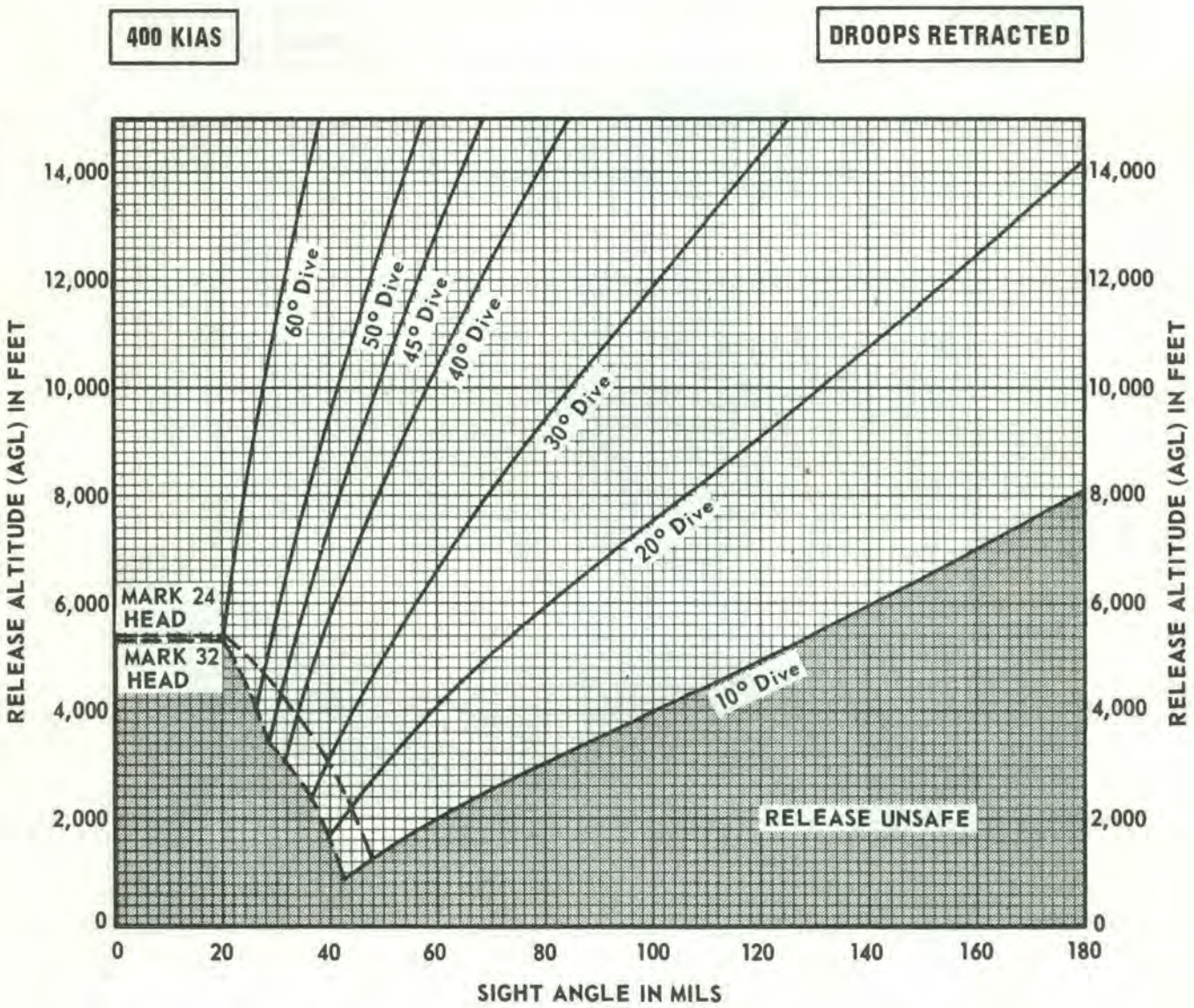
Sight angles are based on 27,000 lb aircraft gross weight, 0 ft burst altitude, and 0 ft target elevation. Rockets launched from LAU-10A/A, LAU-33A/A or LAU-35A/A.

AZ-237(1)-03-69

Figure 2-104 (Sheet 1)

Mil Lead for Single Delivery

5.0 INCH FFAR (ZUNI)



NOTE

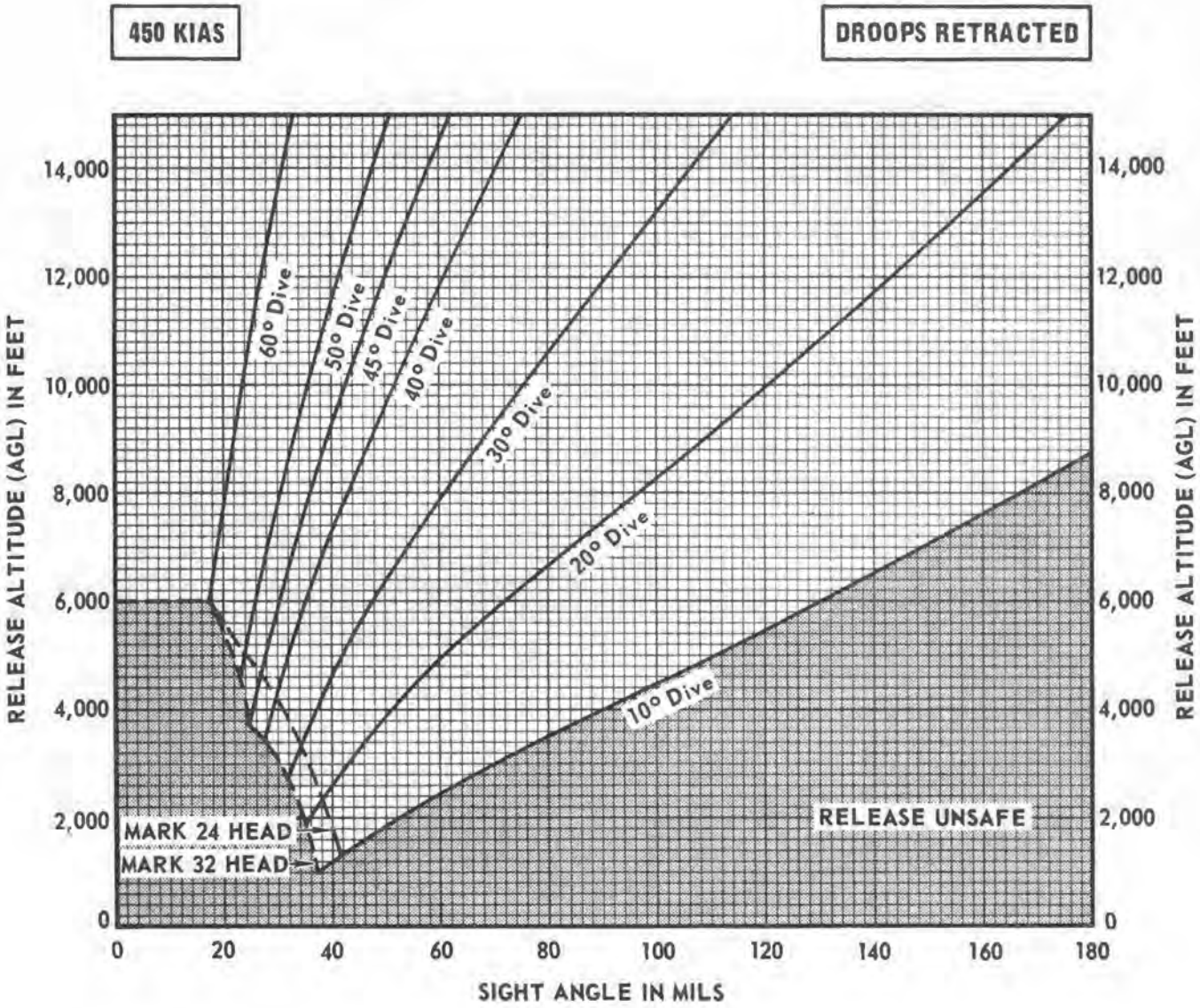
Sight angles are based on 27,000 lb aircraft gross weight, 0 ft burst altitude, and 0 ft target elevation. Rockets launched from LAU-10A/A, LAU-33A/A or LAU-35A/A.

AZ-237(2)-03-69

Figure 2-104 (Sheet 2)

Mil Lead for Single Delivery

5.0 INCH FFAR (ZUNI)



NOTE

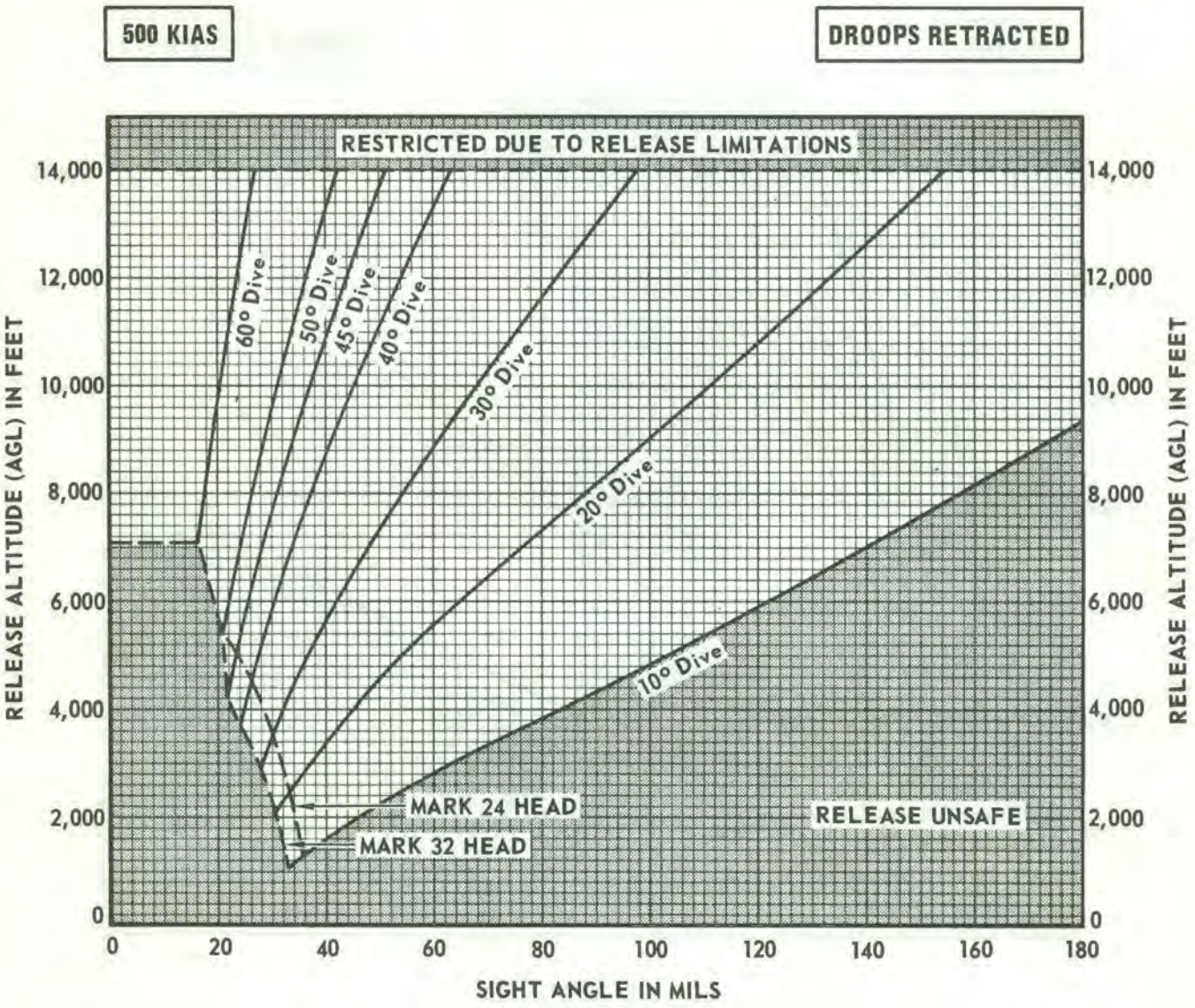
Sight angles are based on 27,000 lb aircraft gross weight, 0 ft burst altitude, and 0 ft target elevation. Rockets launched from LAU-10A/A, LAU-33A/A or LAU-35A/A.

AZ-237(3)-03-69

Figure 2-104 (Sheet 3)

Mil Lead for Single Delivery

5.0 INCH FFAR (ZUNI)



NOTE

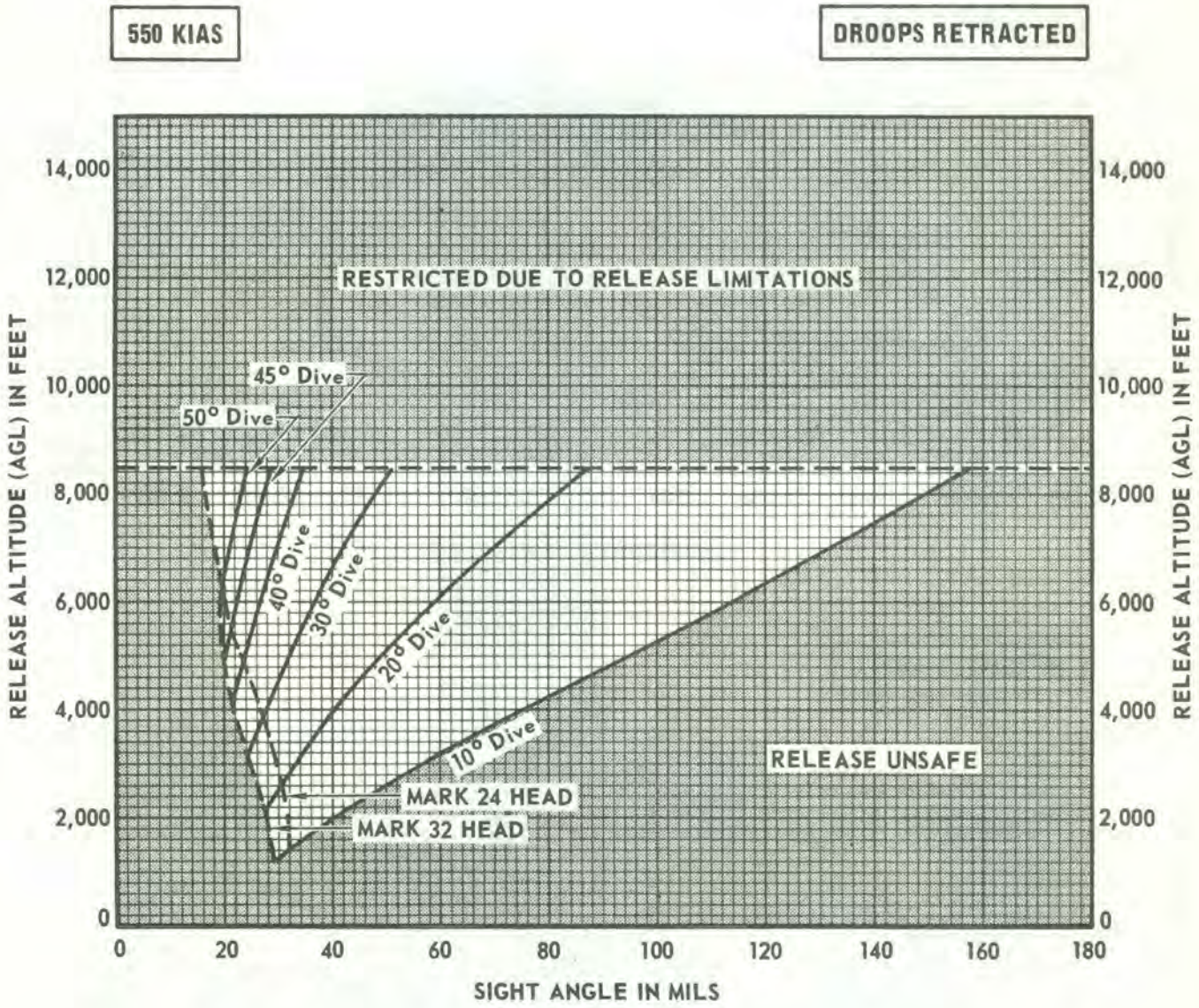
Sight angles are based on 27,000 lb aircraft gross weight, 0 ft burst altitude, and 0 ft target elevation. Rockets launched from LAU-10A/A, LAU-33A/A or LAU-35A/A.

AZ-237(4)-03-69

Figure 2-104 (Sheet 4)

Mil Lead for Single Delivery

5.0 INCH FFAR (ZUNI)



NOTE

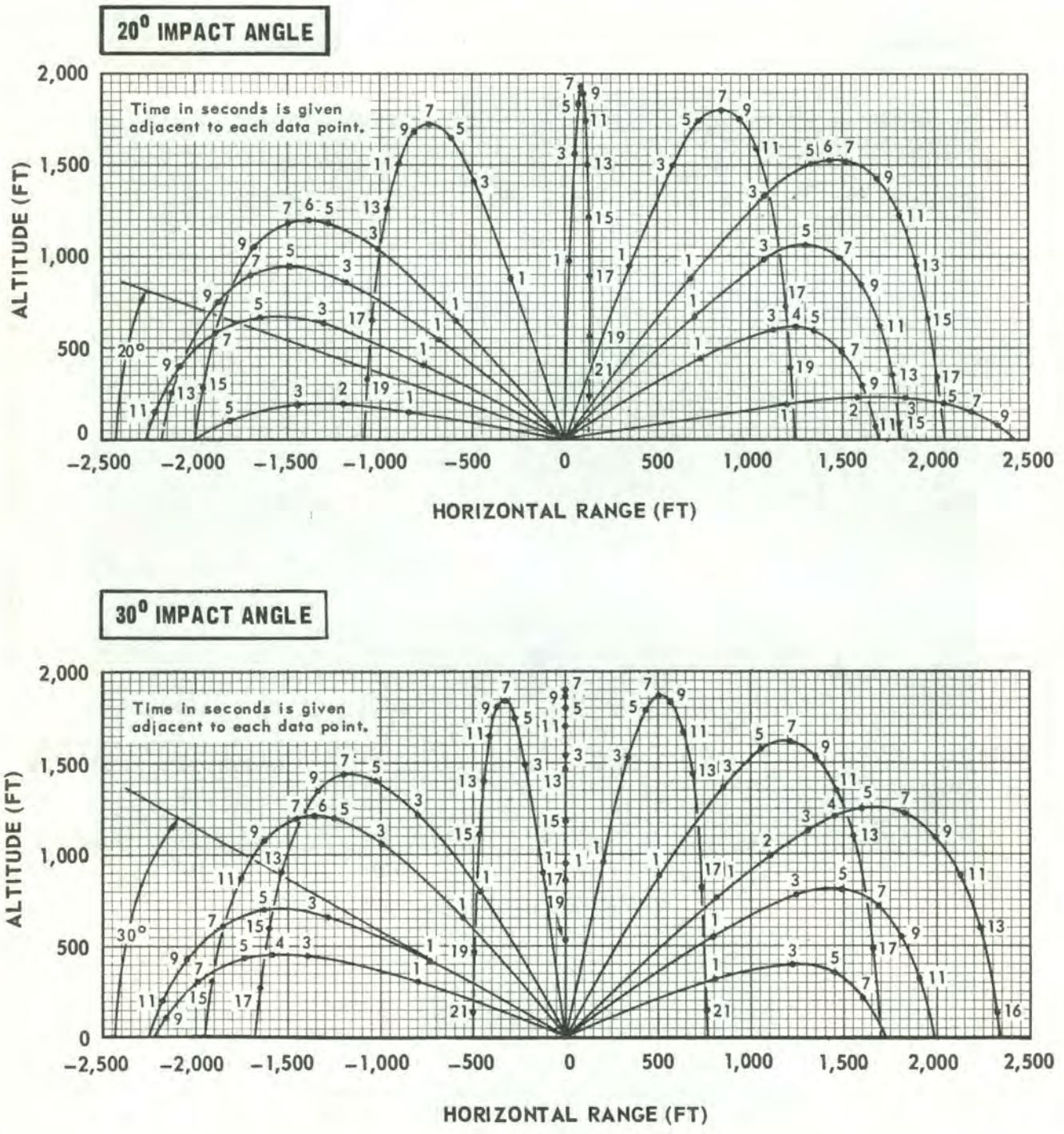
Sight angles are based on 27,000 lb aircraft gross weight, 0 ft burst altitude, and 0 ft target elevation. Rockets launched from LAU-10A/A, LAU-33A/A or LAU-35A/A.

AZ-237(5)-03-69

Figure 2-104 (Sheet 5)

Maximum Fragment Envelope

5.0-INCH FFAR (ZUNI) – MK 24 MOD 0 WARHEAD



AZ–294(1)–5–68

Figure 2–105 (Sheet 1)

Maximum Fragment Envelope

5.0-INCH FFAR (ZUNI) – MK 24 MOD 0 WARHEAD

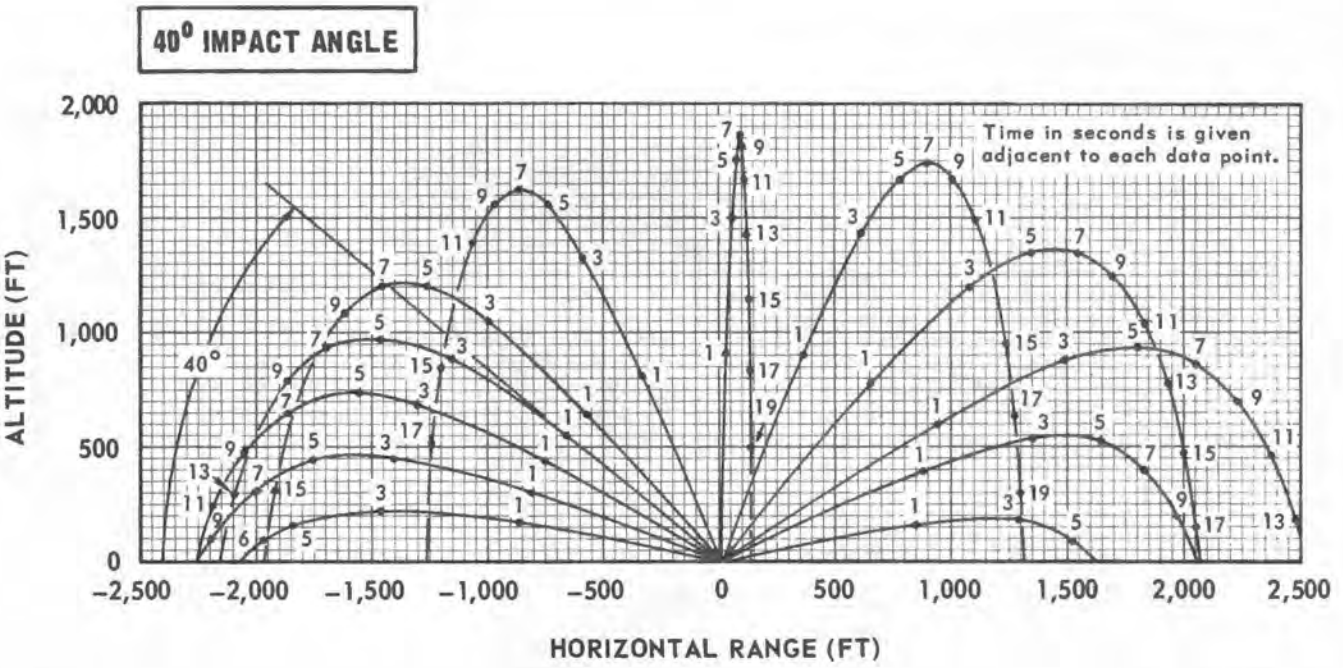
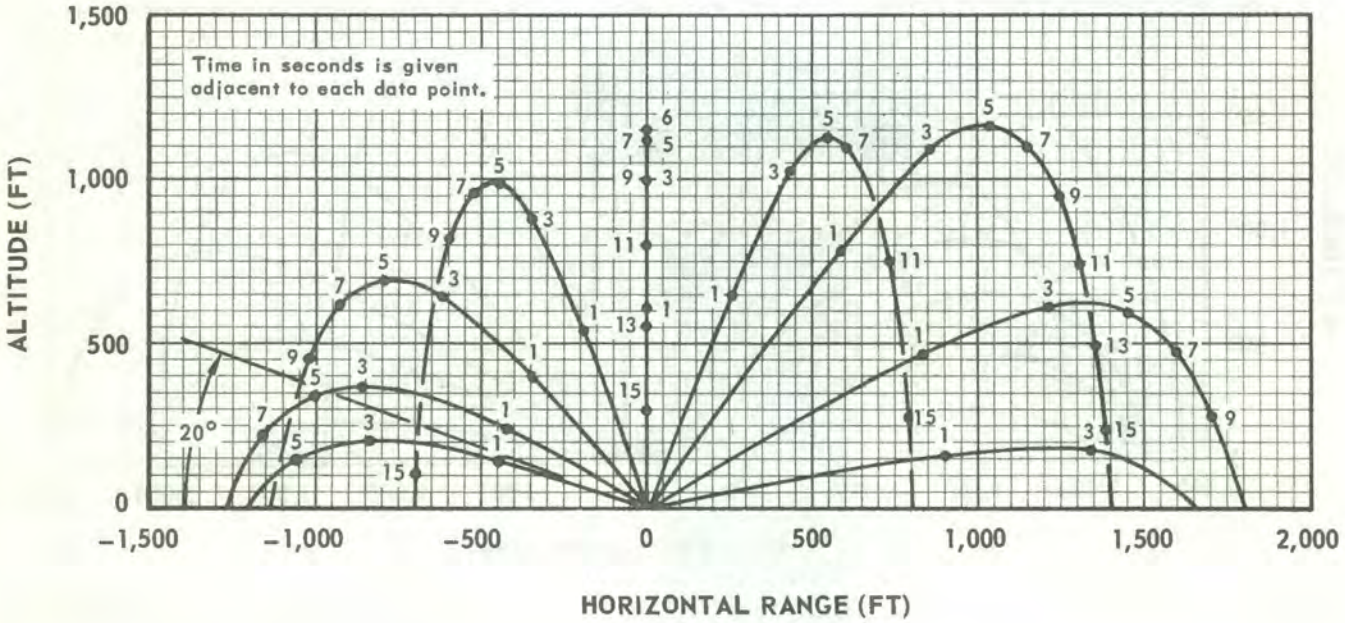


Figure 2–105 (Sheet 2)

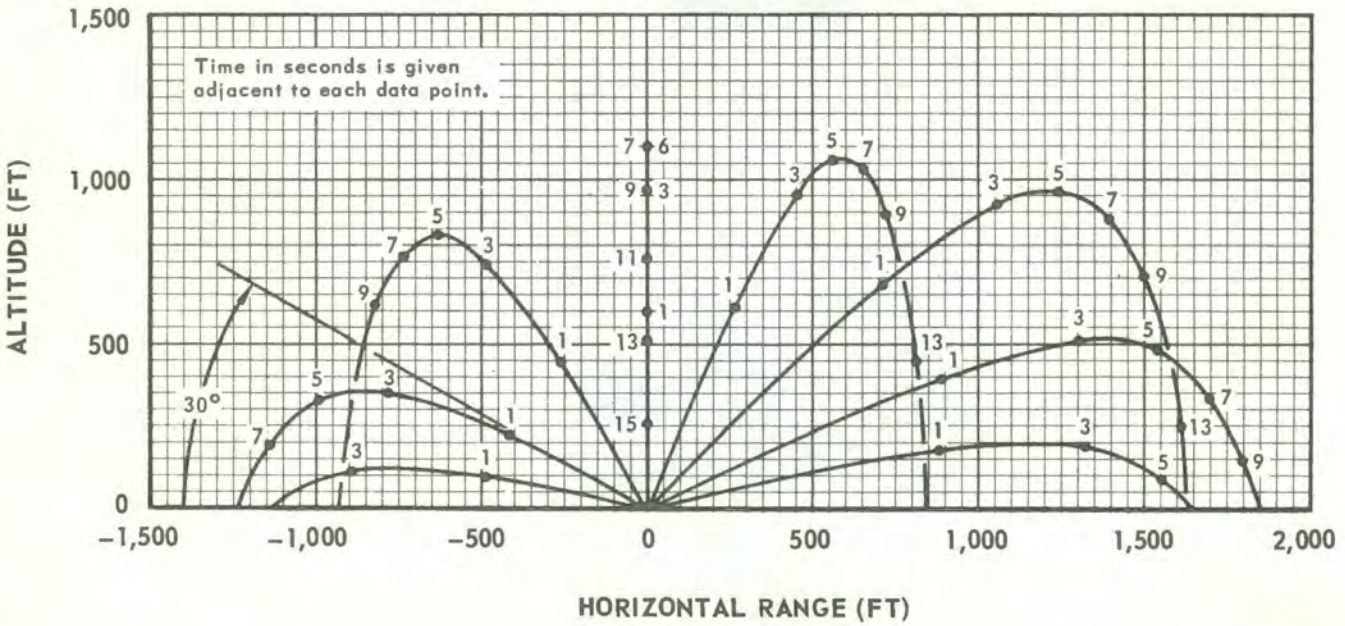
Maximum Fragment Envelope

5.0-INCH FFAR (ZUNI) – MK 32 MOD 0 WARHEAD

20° IMPACT ANGLE



30° IMPACT ANGLE



AZ–295(1)–5–68

Figure 2–106 (Sheet 1)

Maximum Fragment Envelope

5.0-INCH FFAR (ZUNI) – MK 32 MOD 0 WARHEAD

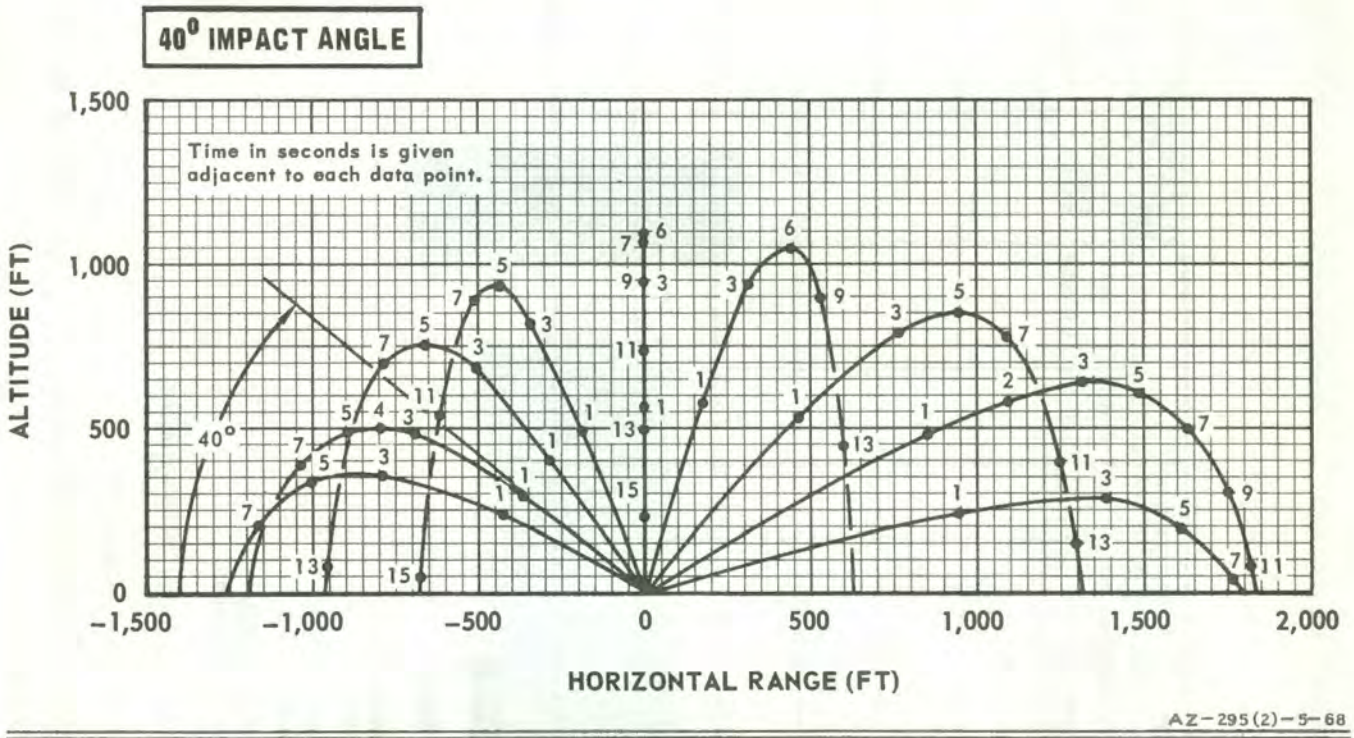


Figure 2–106 (Sheet 2)

5.0 INCH FFAR (ZUNI)

DIVE ANGLE	WARHEAD	MIL LEAD	ENTRY			RELEASE			CORRECTION PER 10KT OF WIND -MILS		RELEASE ERROR SENSITIVITIES				
			KIAS	ALTITUDE FT AGL	APPROX RPM%	KTAS	ALTITUDE FT AGL	ALTIMETER LAG-FT	Range	Cross	FT/10KT KIAS	FT/100FT ALTITUDE	FT/DEG DIVE ANGLE	FT/MIL RANGE	FT/MIL DEFLECTION
10°	MK 32	48	375–400	2,500	92–93	450	800	100	2	6	3	20	10	14	4
20°	MK 32	40	400	5,000	94–96	500	2,000	200	3	7	4.5	10	15	17	6
20°	MK 24	45	400	6,000	94–96	500	2,600	200	3	7	4.5	10	15	17	6
30°	MK 32	35	350	7,000	94–96	500	2,700	250	4	7	2	10	7	12	6
30°	MK 24	40	350	8,000	94–96	500	3,500	250	4	7	2	10	7	12	6
45°	MK 24 and MK 32	45	250	12,000	86–88	450	4,500	0	5	7	2	9	4	8	6

NOTES

1. Error sensitivities are applied as follows:

   Airspeed – Fast impacts long
   Slow impacts short

   Altitude – High impacts short
   Low impacts long

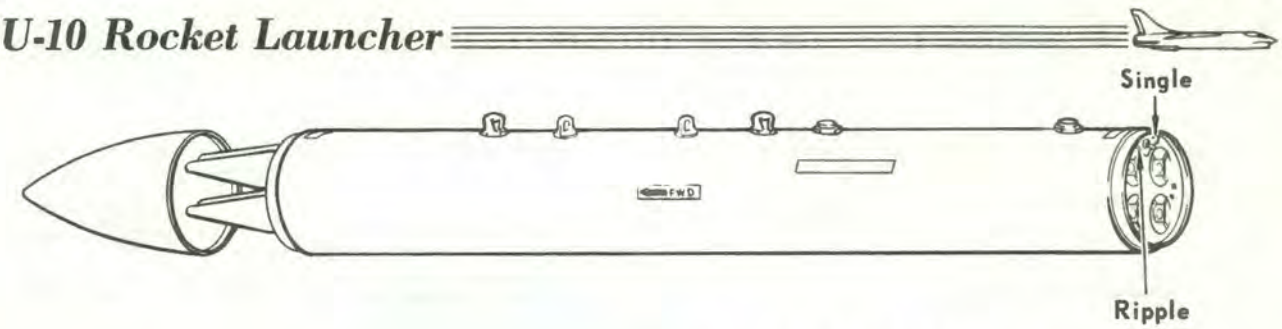
   Dive Angle – Steep impacts long
   Shallow impacts short

2. Mil leads are computed for the cruise droop extended.
3. 45° dive profile flown with speed brakes OUT.

AZ-246-2-67

Figure 2-107

LAU-10 Rocket Launcher



PHYSICAL CHARACTERISTICS

Weight (Empty) – 105 pounds
(Loaded) – 533 pounds
Length – 139.57 inches
Diameter – 13.9 inches
Suspension lugs – 14 and 30 inches apart

DESCRIPTION

The LAU 10/A and the LAU-10A/A are reusable launcher units for shipping, stowing and firing four 5.0-inch FFAR ZUNI rockets. A frangible fairing over each end shatters when the rockets are fired. There is a selectable SINGLE or RIPPLE firing option, however this must be Pre-Set prior to takeoff.

WING STATION LOADING CONFIGURATION		
WING LOADING	**EQUIPMENT**	**WEIGHT**
AERO 7A-1 SUSPENSION One Launcher Each Wing	2 LAU 10/A 2 Aero 7A-1 2 Pylons Total One Wing Only	1066 104 350 1520 760
TER SUSPENSION Two Launchers Each Wing	4 LAU 10/A 2 Aero 7A-1 2 Pylons 2 TER Total One Wing Only	2132 104 350 210 2796 1398

FIRING PROCEDURES

1. Master Arm Sw – ON
2. Armament Sel Sw – Wing L or R
3. Stores Release Sw – DEPRESS

NOTE

When the rocket launcher is carried on the TER the pylon MER/TER switch must be placed in the RKT position to avoid jettisoning the launcher instead of firing the rockets.

To fire rockets from both wings simultaneously the Triple-Multiple Rack Fire Mode switch in each pylon must be set to the DUAL position.

To fire two launchers on the same wing the stores release switch must be depressed twice.

To step the TER stepping switch past an empty station it is necessary to have the hooks at that station open, or the stores release switch must be depressed and released once for each empty station between launchers.

JETTISONING PROCEDURES

See JETTISONING, this section

REFERENCES

1. Restrictions – See Figure 2-2
2. Rocket Launcher Loading, Arming and Pre-flight Inspections – NAVAIR 01-45HH-75

AZ-113-03-69

Figure 2–108

LAU-33A/A and LAU-35A/A Rocket Launchers



PHYSICAL CHARACTERISTICS

Weight	(Empty)	– 72 pounds
	(Loaded)	– 286 pounds
Length		– 93.5 inches
Suspension lugs		– LAU-7/A or Aero 3A Missile Launcher

DESCRIPTION

The LAU-33A/A or -35A/A rocket launchers are dual tube, single or ripple firing launchers. They carry two 5.0-inch FFAR ZUNI rockets.

FUSELAGE LOADING CONFIGURATIONS

FUSELAGE LOADING	EQUIPMENT-WEIGHT
DUAL PYLONS 	3 LAU 33A/A 786 1 LAU 35A/A 262 4 LAU-7/A 348 2 Pylons 140 Total 1536 One Side Only 768
SINGLE PYLONS 	2 LAU 33A/A 524 2 LAU-7/A 174 2 Pylons 108 Total 806 One Side Only 403

FIRING PROCEDURES

1. **Master Arm Sw – ON**
2. **Armament Sel Sw – As Desired**
3. **Stores Release Sw – DEPRESS**

NOTE

The LAU-35A/A was designed for the lower left fuselage station only. The LAU-33A/A can be used in any position except the lower left fuselage station.

Selection of SINGLE or RIPPLE must be made prior to takeoff

JETTISONING PROCEDURES

See JETTISONING this section.

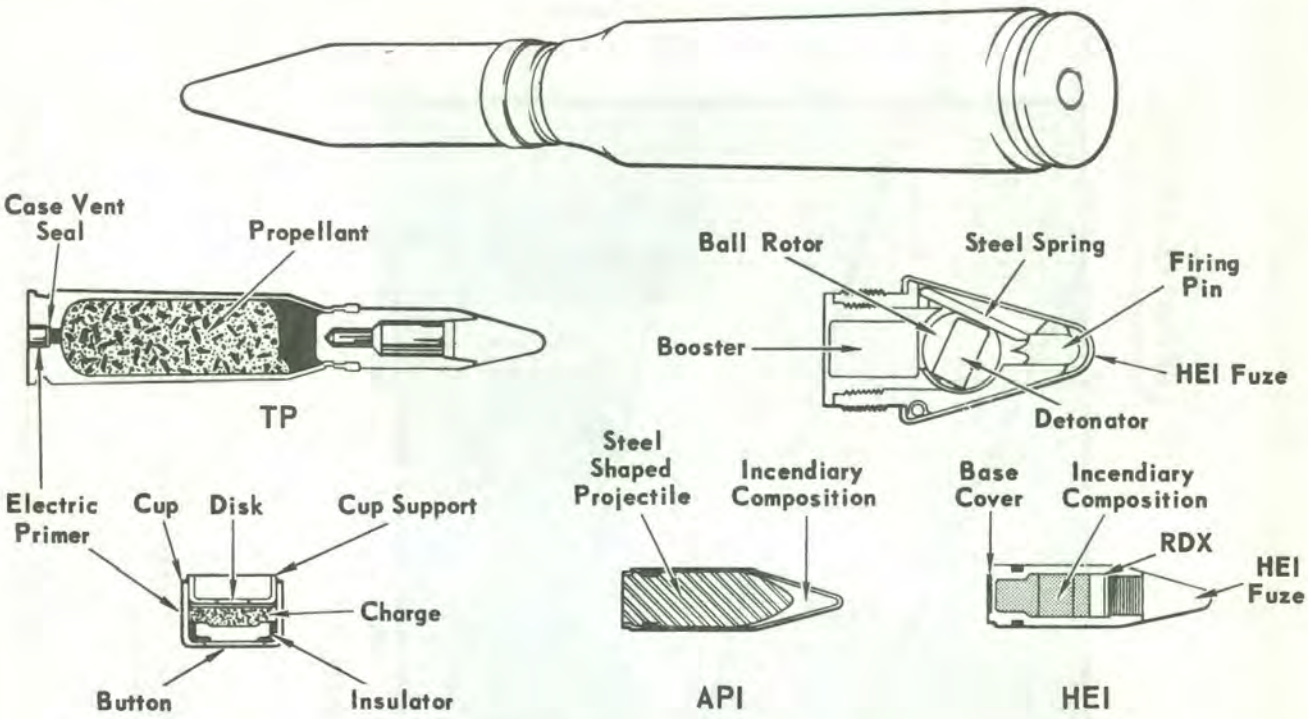
REFERENCES

1. Restrictions – See Figure 2-2
2. Rocket Loading, Arming and Preflight – NAVAIR 01-45HH-75

AZ-116-03-69

Figure 2–109

20mm Ammunition



DESCRIPTION

A 20 MM round consists of a steel cartridge case, an electric primer, propellant powder and the projectile. The primer is ignited by 28 volt DC electrical power from the aircraft armament system. The primer ignites the propellant power which forms a gas as it burns. This gas pressure forces the projectile through the gun barrel. Three types of ammunition are discussed, the only significant difference being the projectile.

The 20 MM ball projectile (TP) is a hollow steel body which does not contain a filler. The use for this projectile is for target practice.

The 20 MM Armor Piercing Incendiary (API) projectile is composed of solid steel. The nose is made of aluminum and charged with an incendiary compound. The projectile requires no fuze.

The 20 MM High Explosive Incendiary (HEI) projectile is composed of an incendiary compound, explosive compound and a fuze. This type projectile is used against aircraft and light material targets.

PHYSICAL CHARACTERISTICS

Weight (Round and Link) – 0.71 pounds
Length – 6.625 inches
Empty (Round and Link) – 0.38 pounds

FIRING PROCEDURES

1. Master Arm Sw – ON
2. Gun Set Sw – ON
3. Guns Arming Sw – READY
4. Trigger Sw – SQUEEZE

REFERENCES

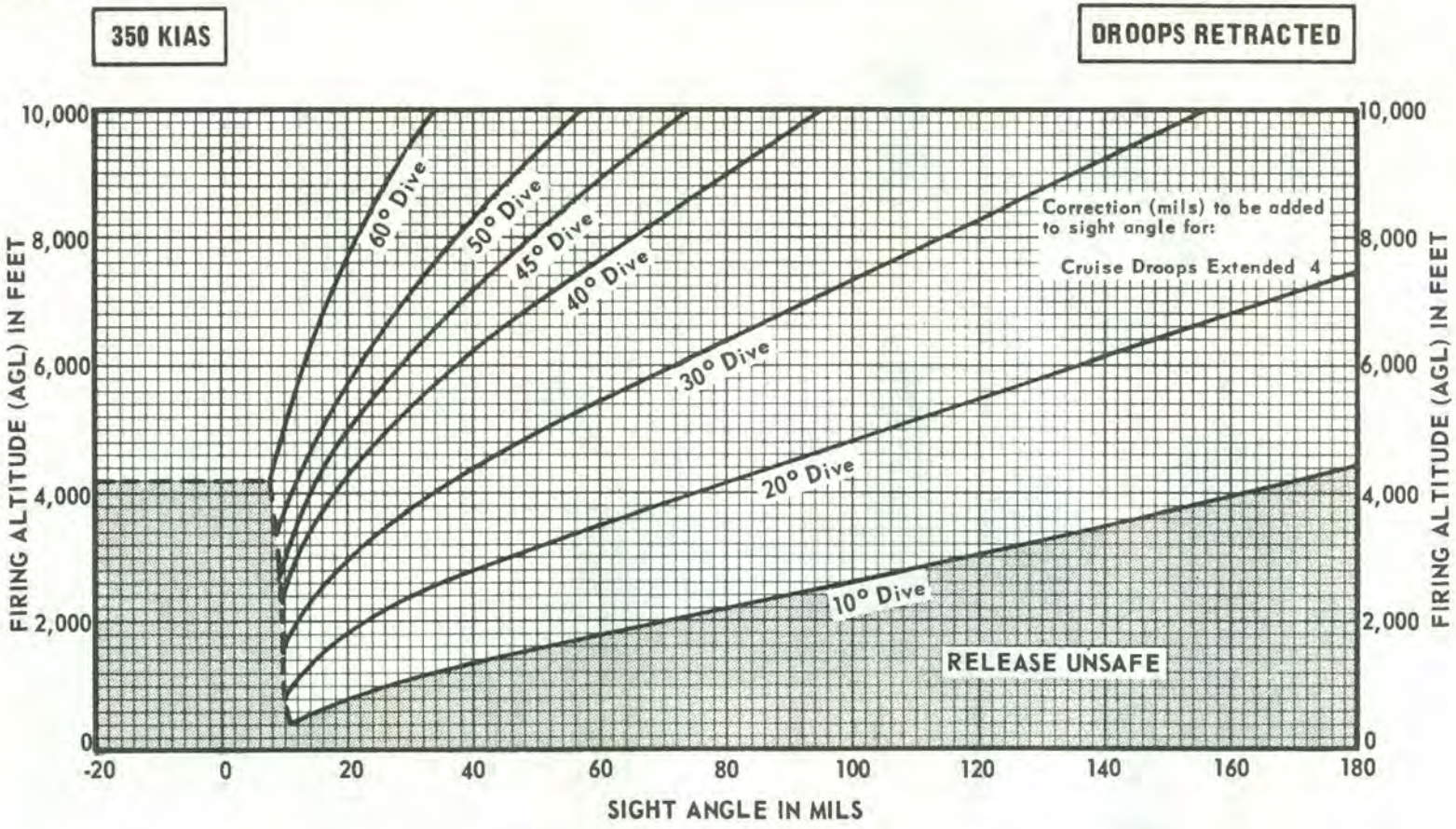
1. Gun Arming – NAVAIR 01-45HH-75
2. Preflight Inspection – NAVAIR 01-45HH-75
3. Gun Loading Procedures – NAVAIR 01-45HH-75

AZ-117-03-69

Figure 2-110

Mil Lead for Strafing

20MM GUNS



NOTE

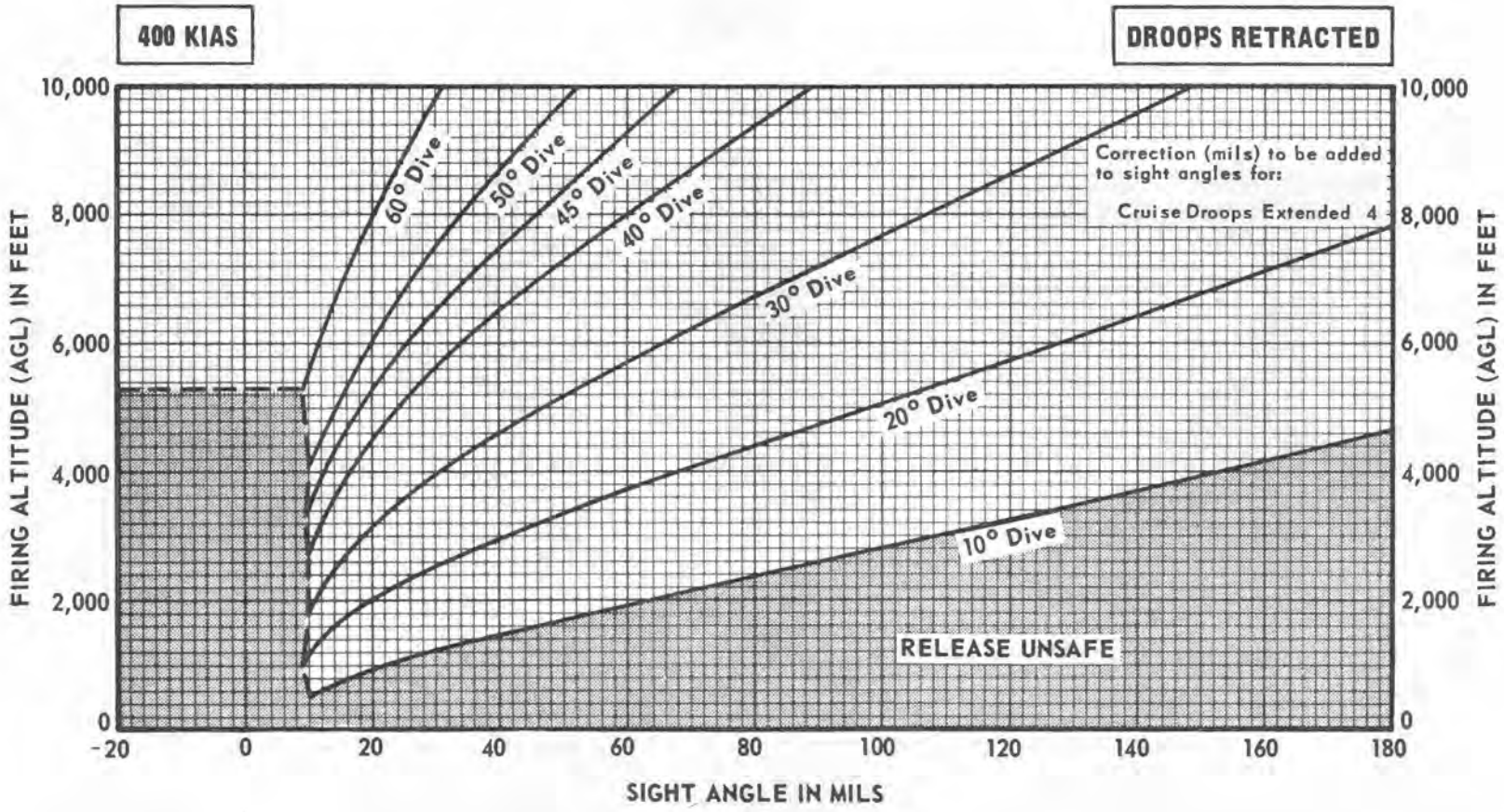
Sight angles are based on 27,000 lb aircraft gross weight
0 ft burst altitude and 0 ft target elevation.

AZ-253(1)-3-67

Figure 2-111 (Sheet 1)

Mil Lead for Strafing

20MM GUNS



NOTE

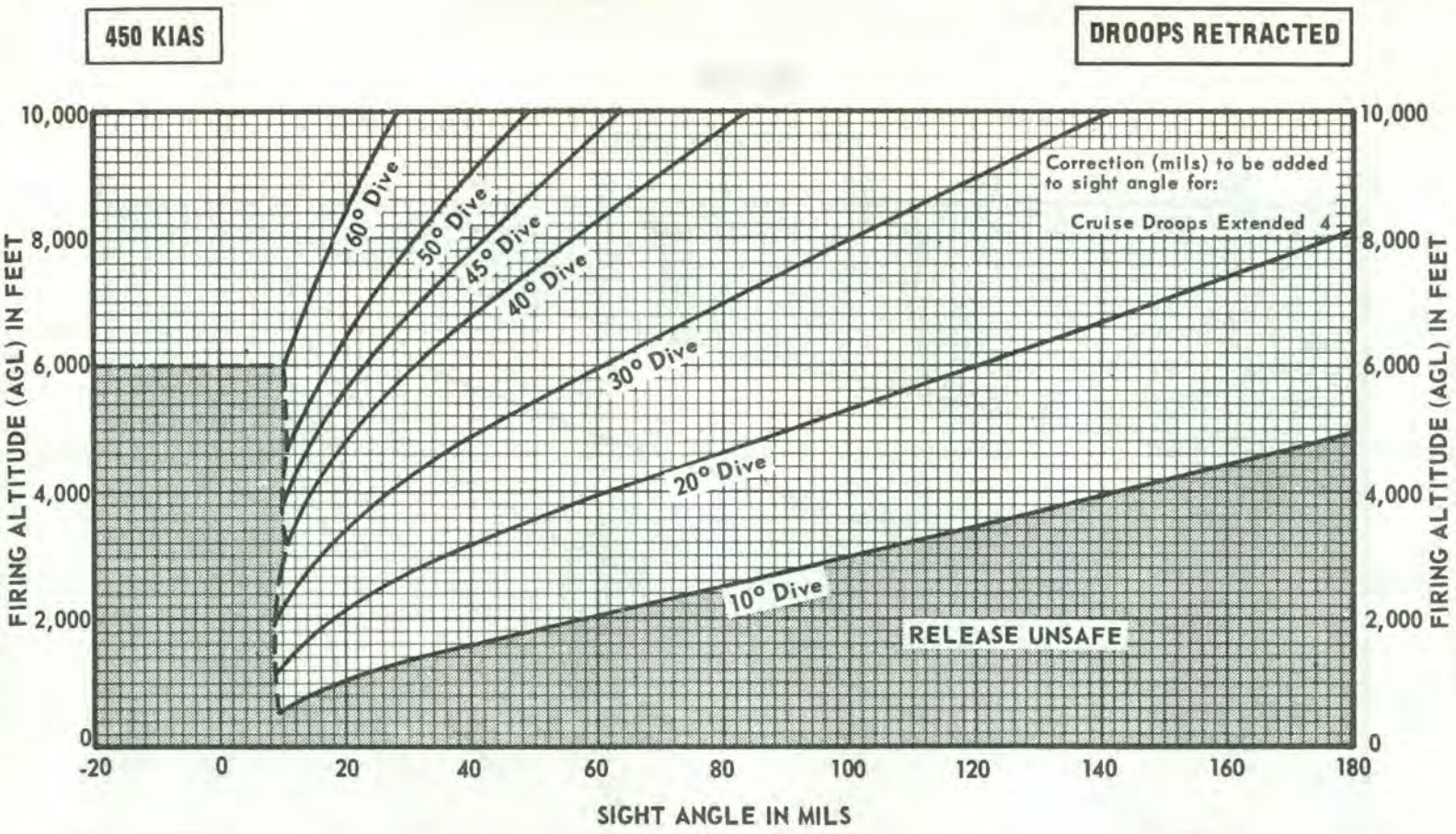
Sight angles are based on 27,000 lb aircraft gross weight, 0 ft burst altitude and 0 ft target elevation.

AZ-253(2)-3-67

Figure 2-111 (Sheet 2)

Mil Lead for Strafing

20MM GUNS



NOTE

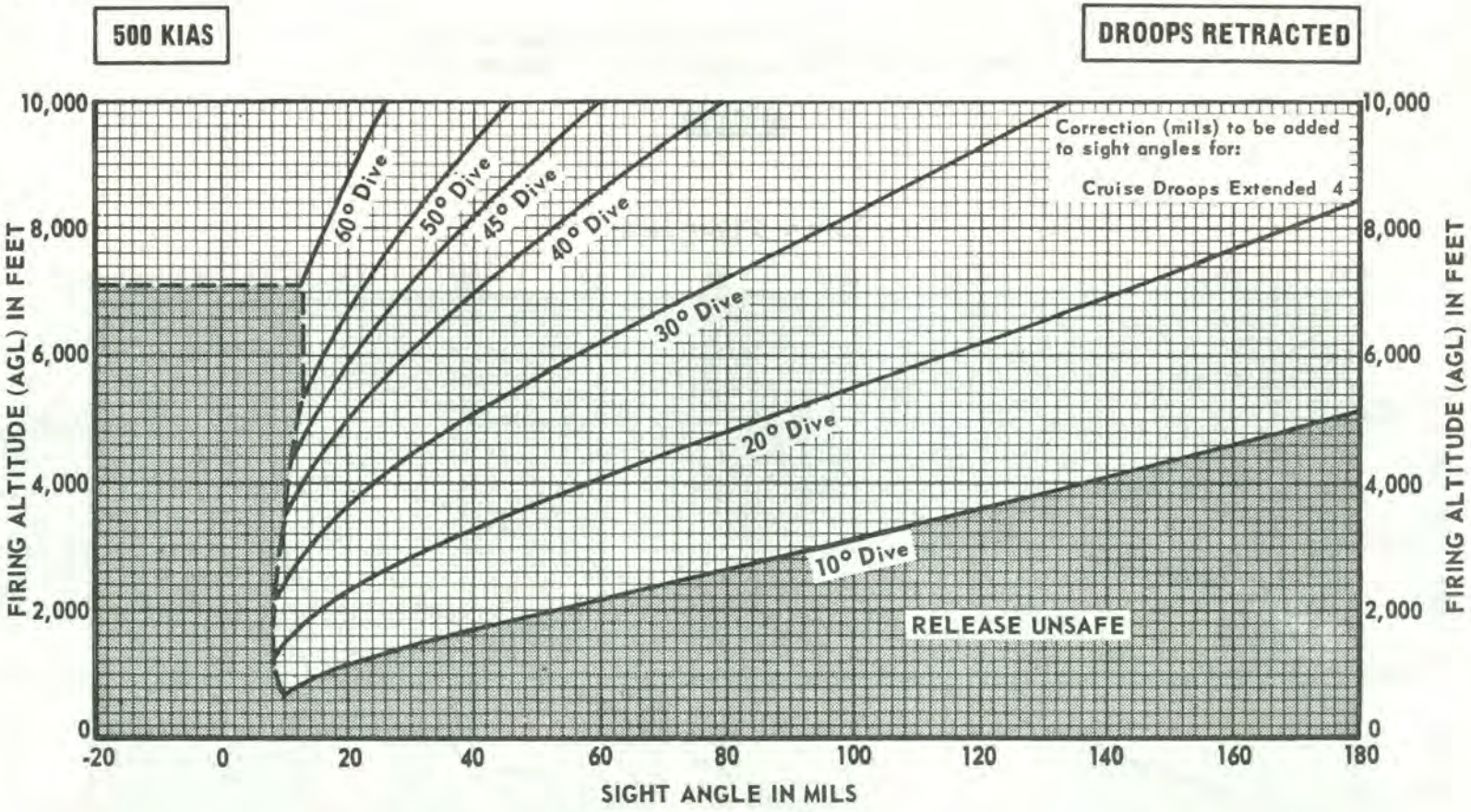
Sight angles are based on 27,000 lb aircraft gross weight, 0 ft burst altitude, and 0 ft target elevation.

AZ-253(3)-3-67

Figure 2-111 (Sheet 3)

Mil Lead for Strafing

20 MM GUNS



NOTE

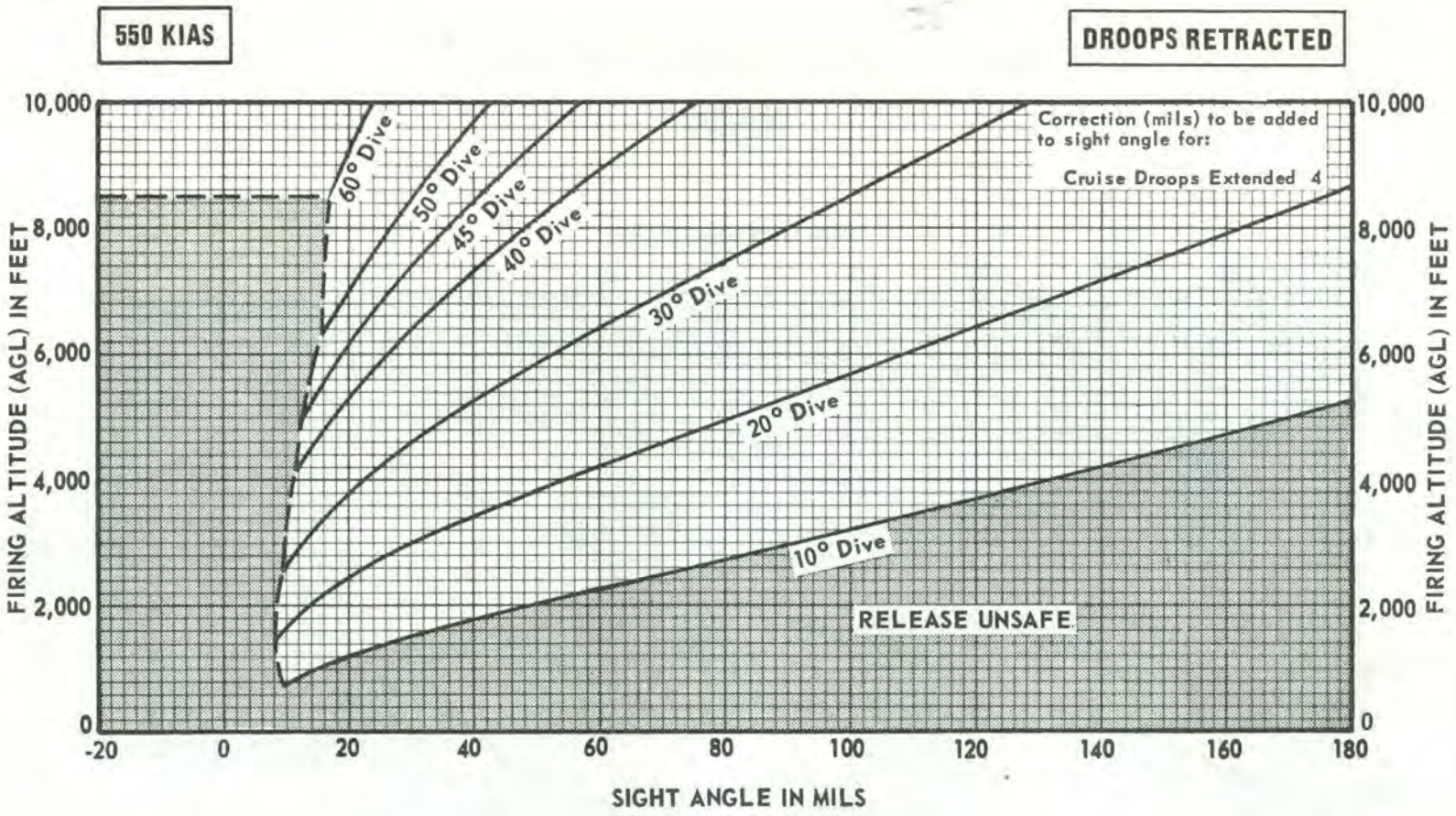
Sight angles are based on 27,000 lb aircraft gross weight, 0 ft burst altitude, and 0 ft target elevation.

AZ-253(4)-3-67

Figure 2–111 (Sheet 4)

Mil Lead for Strafing

20MM GUNS



NOTE

Sight angles are based on 27,000 lb aircraft gross weight, 0 ft burst altitude, and 0 ft target elevation.

AZ-253(5)-3-67

Figure 2-111 (Sheet 5)

Tested Delivery Data

20MM GUNS

DIVE ANGLE	FIRING SIGHT PICTURE 3,000 FEET SLANT RANGE	ENTRY				RELEASE				AVERAGE RECOVERY ALTITUDE FT AGL	CORRECTION PER 10 KT DEFLECTION WIND	
		KIAS	ALTITUDE FT AGL	APPROX RPM %	INITIAL SIGHT PICTURE MILS	KIAS	ALTITUDE COMMENCE FIRING FT AGL	ALTITUDE CEASE FIRING FT AGL	ALTIMETER LAG – FT		MILS	FEET
10°	Pipper 3 mils above top of target	350–400	2,000–2,500	94	5–10 Mils Above Target	450	500	350	100	150–250	5	10
20°	Pipper 3 mils above top of target	350–400	3,500–4,000	92	5–10 Mils Above Target	450	1,000	700	200	200–300	5	10

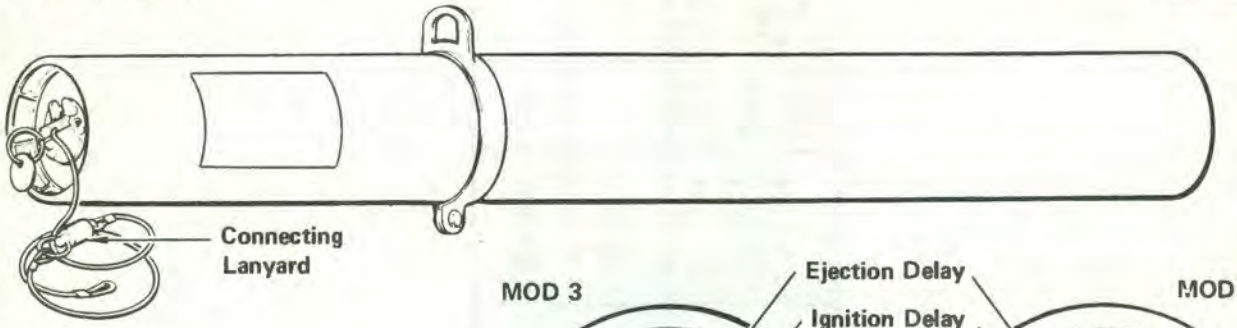
NOTE

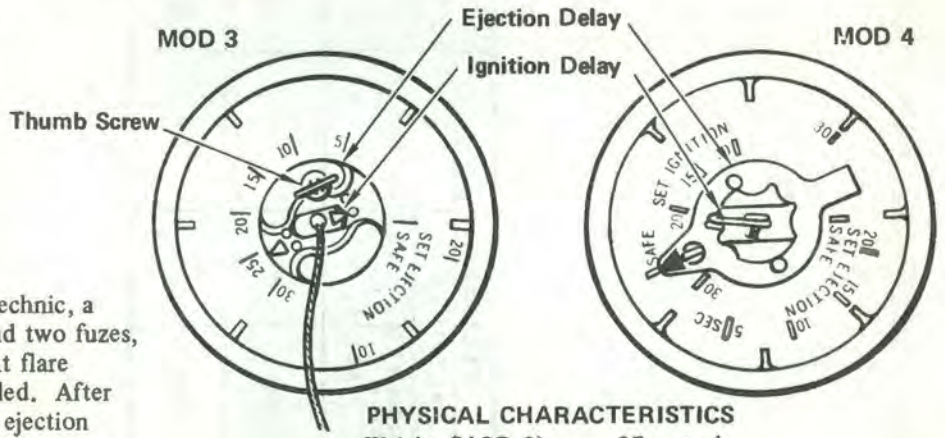
1. Test flown with cruise droop extended.

AZ-248-2-67

Figure 2–112

MK 24 Flare





DESCRIPTION (MOD 3 AND 4)

The Mk 24 Flare consists of a pyrotechnic, a parachute, an ejection mechanism and two fuzes, all enclosed in an aluminum case. At flare release the connecting lanyard is pulled. After a preset delay (0 to 30 seconds) the ejection fuze causes the flare, parachute and ignition fuze to be ejected from the case. When the ignition fuze's preset delay expires, the flare is ignited. Flare burning time is 180 seconds. The MOD 4 flare is contained in and attached to a drogue tray to facilitate installation and ejection from SUU-40/A dispensers.

PHYSICAL CHARACTERISTICS

Weight (MOD 3) – 27 pounds
Length – 36.0 inches
Diameter – 4.8 inches
Suspension – Single Banded Lug

WING STATION LOADING CONFIGURATION		
WING LOADING	**EQUIPMENT**	**–WEIGHT**
PMBR SUSPENSION **Four Flares Each Wing**		
	8 MK 24	216
	2 Aero 7A-1	104
	2 Pylons	350
	2 PMBR	174
	Total	844
	One Wing Only	422
TER SUSPENSION **Two Flares Each Wing**		
	4 MK 24	108
	2 Aero 7A-1	104
	2 Pylons	350
	2 TER	210
	Total	772
	One Wing Only	386
MER SUSPENSION **Three Flares Each Wing**		
	6 MK 24	162
	2 Aero 7A-1	104
	2 Pylons	350
	2 MER	446
	Total	1,062
	One Wing Only	531

DROPPING PROCEDURES

1. Master Arm Sw – ON
2. Armament Sel Sw – Wing L or R
3. Stores Release Sw – DEPRESS

NOTE

For simultaneous release from both wings both Triple-Multiple Rack Fire Mode switches must be in the DUAL position.

To step the MER or TER stepping switch past an empty station, it is necessary to have the hooks at that station open or the stores release switch must be depressed and released once for each empty station between flares. With the –501 or –521 TER or MER, the mechanical fuzing switch must also be placed in the nose position to obtain automatic stepping past the empty stations.

JETTISONING PROCEDURES

See JETTISONING this section.

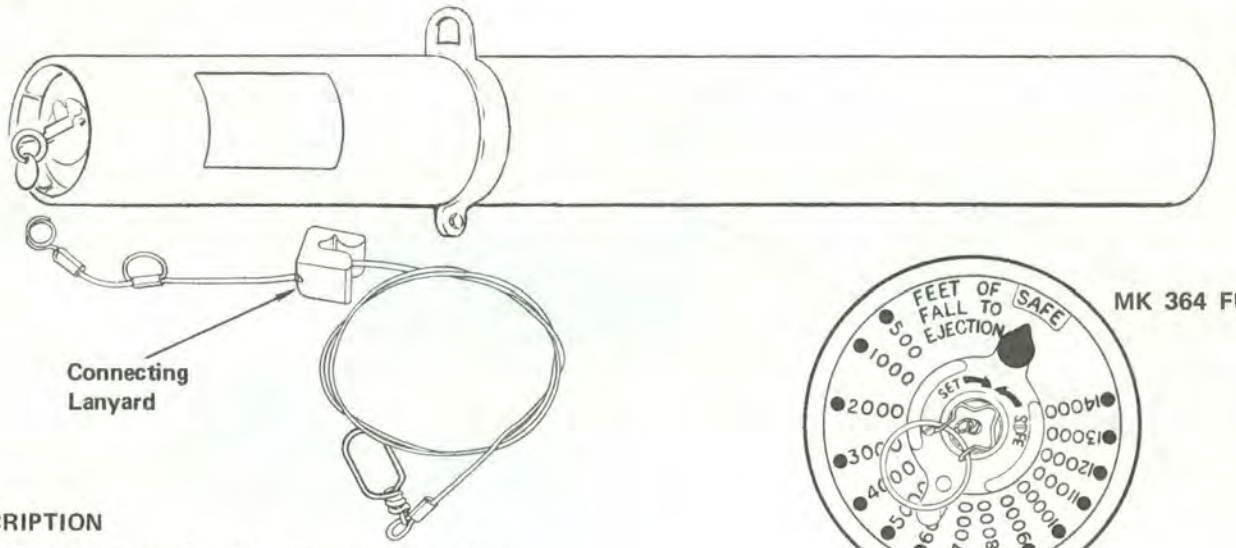
REFERENCES

1. Restrictions – See Figure 2-2
2. Flare Arming – NAVAIR 01-45HH-75
3. Preflight Inspection – NAVAIR 01-45HH-75
4. Flare Loading Procedures – NAVAIR 01-45HH-75

AZ-129-03-69

Figure 2–113

MK 45 Flare



MK 364 FUZE

DESCRIPTION

The MK 45 Flare consists of a pyrotechnic candle, a parachute, an ejection mechanism, and fuze enclosed in an aluminum case. In this flare, the candle is ignited by force exerted by the parachute as it opens. The fuze has 15 functional settings and one safe setting. These settings control the approximate feet of fall between launch and ejection of the candle and parachute assembly from the outer case. Some MK 45 Flares are manufactured and shipped partially assembled in drogue trays for launching from the SUU-40A dispenser.

PHYSICAL CHARACTERISTICS

Weight	– 28 pounds
Length	– 36.0 inches
Diameter	– 4.8 inches
Suspension	– Single Banded Lug, 14 inches

WING STATION LOADING CONFIGURATION		
WING LOADING	**EQUIPMENT-WEIGHT**	
PMBR SUSPENSION Four Flares Each Wing	8 MK 24	224
	2 Aero 7A-1	104
	2 Pylons	350
	2 PMBR	174
	Total	852
	One Wing Only	426
TER SUSPENSION Two Flares Each Wing	4 MK 24	112
	2 Aero 7A-1	104
	2 Pylons	350
	2 TER	210
	Total	776
	One Wing Only	388
MER SUSPENSION Four Flares Each Wing	6 MK 24	168
	2 Aero 7A-1	104
	2 Pylons	350
	2 MER	446
	Total	1,068
	One Wing Only	534

DROPPING PROCEDURES

1. Master Arm Sw – ON
2. Armament Sel Sw – Wing L or R
3. Stores Release Sw – DEPRESS

NOTE

For simultaneous release from both wings both Triple-Multiple Rack Fire Mode switches must be in the DUAL position.

To step the MER or TER stepping switch past an empty station, it is necessary to have the hooks at the station open or the stores release switch must be depressed and released once for each empty station between flares. With the –501 or –521 TER or MER, the mechanical fuzing switch must also be placed in the nose position to obtain automatic stepping past the empty stations.

JETTISONING PROCEDURES

See JETTISONING, this section.

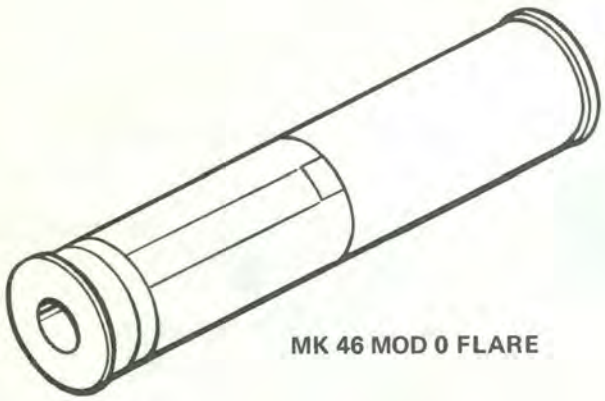
REFERENCES

1. Restrictions – See Figure 2-2.
2. Flare ARming – NAVAIR 01-45HH-75
3. Preflight Inpsection – NAVAIR 01-45HH-75
4. Flare Loading Procedures – NAVAIR 01-45HH-75

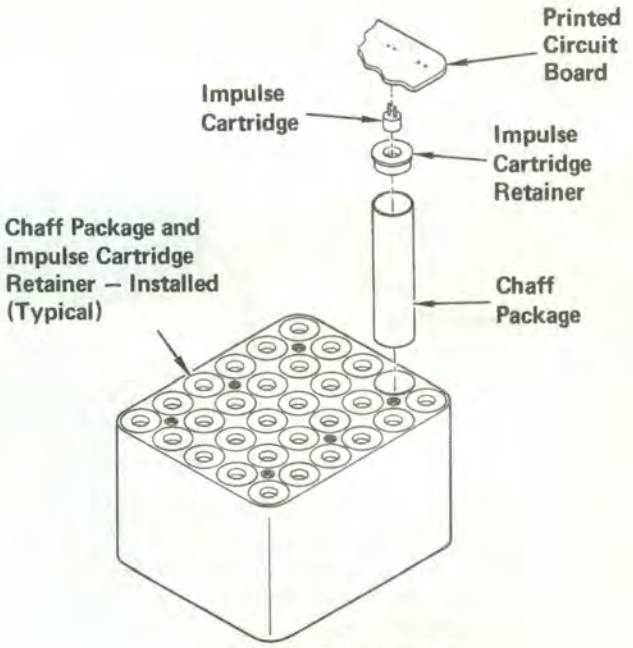
AZ-344-03-69

Figure 1–114 (U)

ALE-29A Chaff Dispenser



MK 46 MOD 0 FLARE



CHAFF DISPENSER

PHYSICAL CHARACTERISTICS

CHAFF DISPENSER			FLARE		
Weight (payload)	–	11.5 pounds	Length	–	5.8 inches
Length	–	9.7 inches	Diameter	–	1.4 inches
Width	–	8.2 inches			
Height	–	6.3 inches			

DESCRIPTION

The AN/ALE-29A dispenser consists of two major subassemblies: a glass fiber plastic block with 30 holes for insertion of the payload packages and a printed circuit board. The circuit board has jacks for installing 30 electrically initiated impulse cartridges and circuitry for distributing the firing signal to the correct cartridge. When the dispenser is loaded, a payload package is loaded in each of the 30 holes. An impulse cartridge is installed in each of the 30 jacks on the printed circuit board. The printed circuit board is then attached to the dispenser. The payload is ejected by gas pressure generated when the impulse cartridge fires.

The Mk 46 Mod 0 flare is launched from the AN/ALE-29A dispenser and is designed to create an infrared source. When the initiation pulse is applied to the impulse cartridge, the expanding gases act against the piston which ejects the firing device and pellet assembly from the dispenser tube at approximately 70-140 fps. The acceleration imparted to this assembly actuates an acceleration sleeve in the firing device, releasing a safety pin on the firing device. When clear of the plastic case and acceleration has been maintained, the safety pin is removed. This allows the firing pin to strike the primer, igniting the flare pellet.

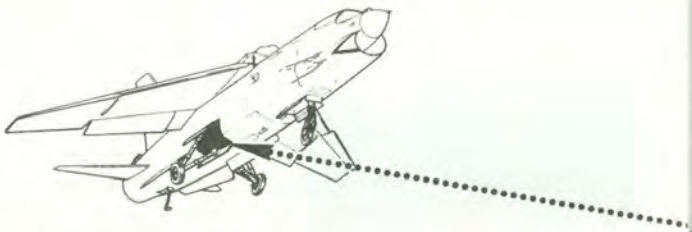
REFERENCES:

1. Dispenser . . . . . NAVAIR 16-30ALE29-3
2. Flare . . . . . NAVAIR 11-15-4
3. Loading . . . . . NAVAIR 01-45HH-75

AZ-355(1)-03-70

Figure 2-115 (U) (Sheet 1)

ALE-29A Chaff Dispenser





PROGRAMMER HOUSING AND DISABLE PIN
(See Detail A for Programmer Panel)



DETAIL A

DISPENSER LOADING
Chaff, RR-129 – 30 ea Dispenser Total – 60 IR Flare, Mk-46 – 30 ea Dispenser Total – 60

DISPENSING PROCEDURE	
PREFLIGHT	AUTOMATIC OPERATION
1. BURSTS, BURST INTERVAL, SALVO and SALVO interval switches on programmer set. 2. RESET switch on programmer – with power on aircraft system, press and hold for 6 seconds after each dispenser loading. (The control panel selector switch must be in FWD, AFT, or BOTH.) The cockpit CHAFF RESET switch may be held in the RESET for 6 seconds regardless of chaff selector switch position. 3. Chaff counters on control panel – press and set to "30". 4. Safety pin removed from firing power disable switch after sequence switches are reset.	1. Control panel selector switch – FWD, AFT, or BOTH as desired. 2. AUTO FIRE switch – press to initiate dispensing of chaff or decoys as selected on programmer. MANUAL OPERATION 1. Control panel selector switch – FWD, AFT, or BOTH as desired. 2. Chaff Manual fire switch – depress once to dispense one salvo of bursts as selected on programmer. Press during automatic operation to dispense one extra burst.

AZ-355(2)-08-70

Figure 2-115 (U) (Sheet 2)

section IV

enemy ground defenses and friendly countermeasures

[refer to (Secret) NAVAIR 01-45HHA-IT(A) (U)]

section V
aircraft employment

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CAP Stationing 5–4

PART 2 – AIR-TO-GROUND WEAPONS DELIVERY

Introduction 5–9
Employment 5–9
External Armament Limitations 5–9
Carrier Operating Limitations 5–9

Section V
aircraft employment

PART 1— AIR-TO-AIR COMBAT

INTRODUCTION

The F-8 is normally employed in two major roles: air-to-air combat and air-to-ground weapons delivery. In the air-to-air role, the F-8 is used as a fighter for target CAP, barrier CAP, force CAP, escort, and weather reconnaissance. Use of the F-8 in a combined role (air-to-air and air-to-ground) during the same flight is not recommended. Wing racks and pylons which are installed for the air-to-ground mission (and cannot be jettisoned) will significantly degrade the aircraft's air-to-air capability. The F-8 will not turn, climb or accelerate as well with wing stores or racks. In addition, wing stores reduce the acceleration (g) limits of the aircraft.

EMPLOYMENT

When used as a fighter, standard armament loading should be two Sidewinder missiles and a full load of 20mm ammunition. AIM-9Ds should be installed on single pylons. The basic fighting element is the two-aircraft section using loose deuce tactics.

TARGET CAP

The F-8 is ideal for providing close-in protection for friendly attack aircraft. Should enemy air opposition develop, the resulting mix of friendly and enemy aircraft may preclude the use of air-to-air missiles. In such a case guns should be relied on as the primary weapon. TARCAP is flown with either one or two F-8 sections, in a ratio of about one fighter for every four attack aircraft. TARCAP aircraft should be tanked enroute to provide maximum fighting fuel in the target area.

BARRIER CAP

The F-8 can be used as BARCAP, stationed between friendly aircraft and the expected threat. In particular instances, it is useful to establish selected and number-designated geographic holding points. This information is passed to the SAR destroyers so that flights may be positioned at any specific point they request without compromising their intentions. If more than one section is available, the sections can be stationed in mutually supporting positions, although not necessarily in visual contact. At night the section is separated by altitude levels and maintains either a radar trail formation or an individual tactical pattern relative to a preselected TACAN position. BARCAP flown at night or in IFR conditions without visual reference to land or sea must be under positive control.

ESCORT

In an escort role, the F-8 can provide protection for attack, photo, and ELINT mission aircraft. The standard fighter armament of a full load of 20mm and 2 AIM-9D missiles is recommended.

Attack escort is essentially a TARCAP mission that provides the attack formation air cover to and from the target, as well as in the target area. TARCAP considerations discussed above apply.

Photo escort can be conducted by a single F-8 unless the probability of air opposition dictates the use of a section. Cycle times in excess of 1 hour and 45 minutes may require F-8 tanking.

ELINT escort can be flown by the F-8 but certain sacrifices in aircraft performance will be necessary in some situations. Escorting EA-3B and RA-3B aircraft presents little problem to the F-8. Standard loose deuce tactics will provide adequate cover. Escorting EC-121 and C-130 aircraft visually will necessitate slow fighter speeds and distances of from 2 to 5 miles between the fighter and the ELINT aircraft. If enemy air attack is encountered under such conditions, it would be difficult for the F-8's to get in position for protection soon enough. If AEW or destroyer control is available, it should be utilized to keep the fighters in the vicinity of the ELINT aircraft. The fighters can then keep up their airspeed and be in a better position to intercept incoming raids. When escorting ELINT aircraft, F-8 radar use must be limited.

FORCE CAP

When the F-8 is employed as a fighter interceptor, basic armament loading can be four Sidewinder missiles and a full load of 20mm.

The F-8 weapon system can be employed in anti-air warfare defense of the force by two basic methods. It can be flown on sustained CAP or maintained on short notice as a DLI. The most important advantages of the CAP are that it accelerates the task force reaction time and extends the anti-air defensive envelope. However, a sustained CAP may exhaust the reserve aircraft within a few hours and thus reduce the total task force armament. The use of DLI generally shortens the defensive envelope but maintains a higher sustained total readiness. In actual practice it may be advantageous to mix or vary the methods as befits the tactical situation. This section presents the important considerations that affect the employment of the F-8 in a task force environment. However, the principles are also

valid and applicable to the problems associated with land-based defense.

The mission of the task force usually generates the requirement for air-to-air defense. The mission is determined by higher command and is beyond the scope of this manual. However, the mission may place several restraints on the selection of CAP or DLI defenses. For example, the nature of the mission will dictate the type of action, the required movement of the Position of Intended Movement (PIM), and the extent of deck preparations for launching attack airplanes.

The greatest asset the carrier has over the land base is mobility. However, the ability to move as far as 600 NM per day is frequently not compatible with sustained air operations unless movement of the PIM is into the wind. The interference with PIM movement has a direct bearing on the decision to maintain a CAP. Figure 5–1 illustrates how the PIM is adversely affected by the duration of the land/launch time into the wind, the CAP cycle time, and the angle between the PIM direction and the land/launch heading.

If the conditions imposed by the requirement for mobility cannot be met by the carrier, then either the conditions will have to be changed or DLI will have to be employed. The task force mission may call for immediate preparations for launching a large scale attack effort. The extent of the preparations and launch are likely to either impede the land/launch operation of CAP fighters, or to tie up the ready catapults of the DLI.

Early Warning Radius

The task force early warning radius is one of the most important factors affecting the choice of CAP or DLI. Early warning provides time to evaluate before acting. Every minute required to complete the cycle of reaction is equivalent to 8 to 15 miles of early warning range (depending on raid speed). It is most important to note that the early warning radius is highly variable and difficult to measure because it is affected by atmospheric conditions; relative stationing of friendly ship, air and shore sites; electronic status of the individual sites; and the speed, position and altitude of the threat. Generally, a long early warning radius permits the use of DLI while a short radius negates their practical value.

Deck Launch Interval

The time required to launch the first DLI and the rate of launch of the succeeding DLI are important factors to consider. It is affected by the condition of readiness of pilots, aircraft, and ship, and by the turn into the wind necessary to meet the launch wind requirement. The rate of launch of the succeeding DLI determines how many fighters will engage the raids. It is primarily a question of the reserve aircraft available and the capability of the ship to launch them. Launch rate may be slowed appreciably at night and/or in poor weather conditions.

Weather and EMCON Conditions

Weather and EMCON conditions considered separately or together have a major effect on fighter employment and effectiveness. In adverse weather the carrier's into-the-wind time for CAP recovery may seriously affect its ability to make good its PIM. A combination of adverse weather and EMCON conditions can further complicate CAP employment, for with no radiating navigational aids or radars in operation, the CAP cannot maintain station. The use of DLI would be forced. A request for DLI by early warning pickets or aircraft would necessarily require breaking of the EMCON condition.

One solution is to employ a long range CAP, stationed in the expected threat quadrant, as a barrier patrol with no AI radar emission restrictions. Return navigation would require skillful AI radar techniques on the part of the CAP to effect its own approach.

CAP STATIONING

CAP is used in defense of a task force for several reasons. It will provide the most rapid method to engage enemy raids, to identify incoming unknowns, and to augment the early warning information. Basically, there are only five possible CAP station locations. They are low-near, low-far, high-near, high-far, and long range. The selection of the correct CAP stations to fit the tactical situation depends upon several important factors. They are: the nature of the threat; the area to defend; the supporting air defense weapons; the number of fighters available and their cycle time; the extent of the early warning and communications perimeters; and the EMCON condition. The following paragraphs will discuss the effect of these factors on the five CAP stations.

LOW-NEAR CAP STATION

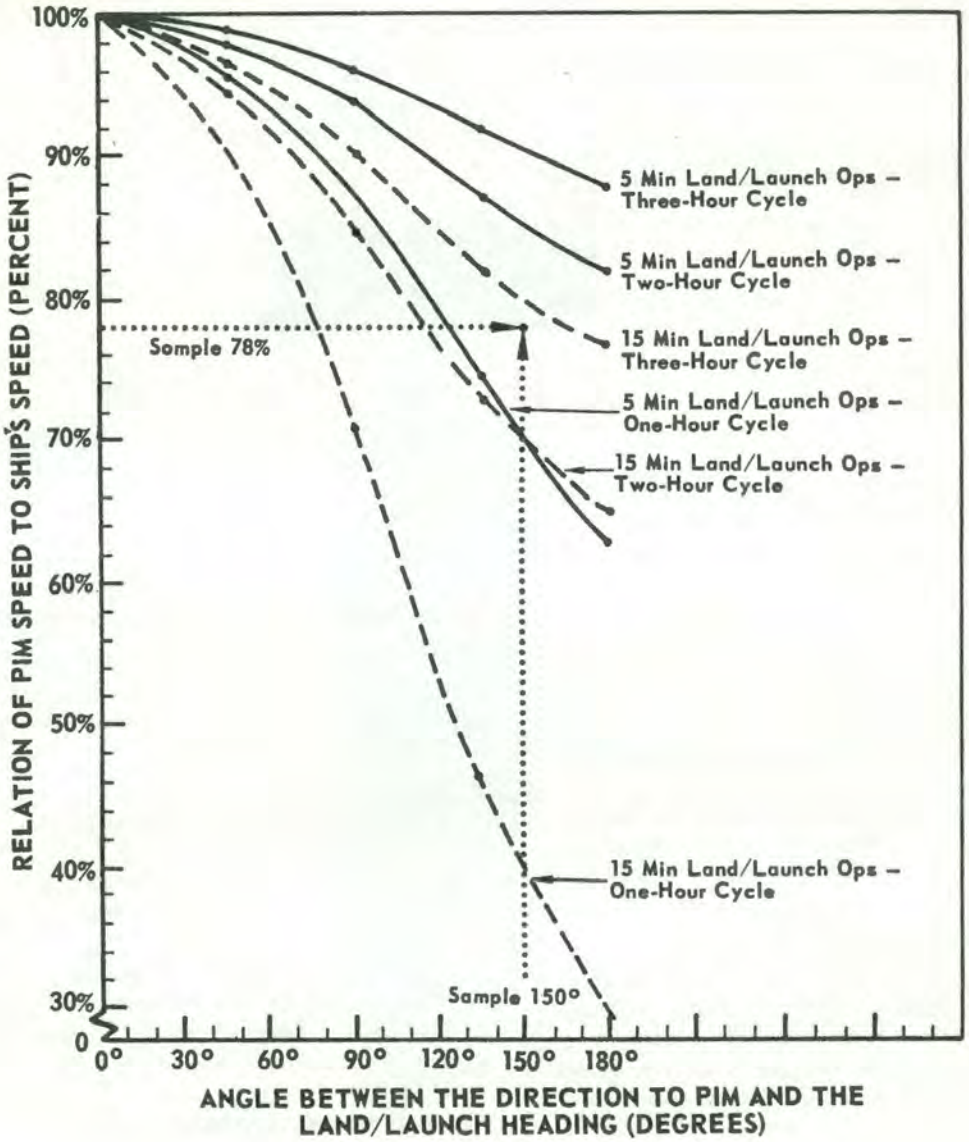
The low-near CAP station is defined as being close to or in the vital area at an altitude, commensurate with the weather, which will permit immediate arrival at co-altitude with low flying raids. If the fighter's radar is being used as an AEW gap-filler against low flyers, then the altitude of the CAP station should be determined by the ducting levels and sea state. It will frequently be at co-altitude with the low raids. The low-near CAP station has the following characteristics:

Advantages

a. Permits early detection and attack of low flyers and descending raids.

b. Provides all-quadrant protection for vital area against all types of raids.

CAP Employment Factors



Assumptions:

Ship's air-operation speed and cruise speed is the same. Ship's rate of turn 45 degrees per minute. Launch and CCA recovery of each aircraft requires 5 minutes.

Condition:

PIM – 21 Knots.

Ship Speed – 27 Knots.

Angle between the direction to PIM and Land/Launch heading – 150°.

Solution:

Divide PIM Speed by Ship's Speed. 21 divided by 27 = 78%. Draw line horizontally from 78% and vertically from 150°.

Answer:

1 CAP on a 1½ hour cycle, 2 CAP on a 2-hour cycle or 3 CAP on a 2¾ hour cycle.

AZ-147-2-67

Figure 5-1

c. Permits all of the fighters to bear on raid.

d. Permits fighter maneuvering below friendly SAM zones.

e. Retains fighters within radar and communications range of ships.

f. Allows fighters to maintain visual station on ships during day-VFR weather, under EMCON conditions.

g. Reduces possibility that enemy long range surveillance radar will be able to see CAP.

h. Provides minimum susceptibility to communication jamming.

i. Provides small CAP station radius.

Disadvantages

a. CAP cannot engage raids near limits of early warning range.

b. Reduces cycle time about 10 percent from optimum.

In general, the low-near CAP station should be the best tactical CAP station for the F-8 when used in one or two carrier independent task forces. It makes maximum use of the capability of a small number of airplanes to detect and intercept low flying targets, descending raids, and mid-altitude saturation raids from all quadrants. It should permit employment of SAM missiles and CAP jointly. At the same time it should allow maximum reliability of communications, control, and navigational aids.

The low level CAP station is very adaptable to the F-8. The look-up capability of the radar is better than the look-down (detection of higher altitude targets). The primary weapon, the Sidewinder, is a most effective air-to-air weapon for the destruction of low flying jet targets. The aircraft has the ability to climb from sea level to 35,000 feet in 3 minutes, if necessary to intercept medium or high altitude raids. Its ability to descend is equal only in fair weather, daylight conditions.

LOW-FAR CAP STATION

The altitude of the low-far CAP station is determined by the same criteria as the low-near CAP station. The positioning of the low-far CAP station may vary from just beyond the effective radar/communications horizon of the task force to about one-half the early warning range. The low-far station has the following characteristics:

Advantages

a. Permits CAP to detect and intercept low flying and descending targets at extended ranges in one quadrant.

b. Provides one-quadrant extended intercepts and identification runs against higher flying raids.

c. Permits CAP operations closer to, but below enemy surveillance radar.

d. Separates the fighters from friendly SAM zones, vertically and horizontally.

e. Provides small CAP station radius.

Disadvantages

a. Requires picket ship or AEW control for high order of effectiveness.

b. Provides only one-quadrant protection unless large number of fighters are used.

c. Requires electronic aids unless station is oriented over geographic point or picket ship during day VFR.

d. Reduces cycle time about 10 to 15 percent from optimum.

e. On-station time reduced about 15 minutes for every 50 miles of distance from the carrier.

In general, the low-far CAP station is most advantageous if only one quadrant requires protection, or if enemy surveillance radar overlaps the task force or beachhead zones of influence.

An F-8, for example, is capable of launching and proceeding to a CAP station 100 miles from the force at sea level. Deducting the fuel required for landing reserve (1,500 pounds) and transit to and from station, a combat or loiter package of 4,800 pounds is available. This is enough to allow about 1 hour and 10 minutes of surveillance on station at maximum endurance, or 50 minutes of loiter and 15 minutes of sea level combat at 500 knots. Total cycle time available would be approximately 1 hour and 45 minutes.

HIGH-NEAR CAP STATION

The high-near CAP station is defined as near or over the vital area at an altitude that conflicts with friendly SAM zones, or from which a fighter, commensurate with weather, would require a substantial length of time to descend to the altitude of a low flyer. The high-near CAP station has the following characteristics:

Advantages

a. All-quadrant protection against medium and high altitude raids.

b. Maximum cycle time.

c. Concentrates fighters against raids.

Disadvantages

a. May be unable to detect or attack low flyers or descending raids.

b. Conflicts with friendly SAM zones.

c. Can be used by enemy long range surveillance radar to locate task force.

d. Large CAP station radius.

In general, the high-near CAP station utilizes the capability of the F-8 only when the task force does not have conflicting SAM zones, and all-quadrant protection against medium and high raids is desired. Additional CAP stations (low) must be provided for low level targets.

HIGH-FAR CAP STATION

The high-far CAP station is located about 50 to 150 miles from the vital area. The altitude of the high-far CAP station is the same as that of the high-near CAP station. The high-far CAP station has the following characteristics:

Advantages

a. Permits intercepts and identification runs against medium and high altitude raids at extended ranges in one quadrant.

b. Does not require picket ship or AEW for communications and control.

c. Separates the fighter from friendly SAM zones.

Disadvantages

a. Usually unable to provide protection against low flyers and descending raids unless raids remain at altitude until reaching the high-far CAP station.

b. Does not provide all-quadrant protection for vital area.

c. Cannot be used when enemy GCI zones overlap task force zones.

d. Reduces on-station time about 15 minutes per 50 miles of distance from carrier.

e. Provides large CAP station radius.

In general, the high-far CAP station utilizes the capability of the F-8 when one-quadrant protection against medium and high altitude raids only is desired, and picket and/or AEW control is not available.

Included in a decision to use any fighter on a high CAP station must be the consideration of the CAP capability to intercept or detect the low level target or descending target. An attack against a descending target is one of the most difficult to make. This is the preparatory maneuver to an ASM launch. Radar look-down performance is poor. The descending attack is difficult to execute and places the fighter employing the Sidewinder missile in its most disadvantageous position in terms of IR contrast and detection. Also, the missile aerodynamic envelope is more limited in a descending attack than in an attack from any other aspect. The time required to descend from high to low altitude to attack a low level target is at least equal to, and in most cases greater than, that required to climb for an intercept. In addition, effective radar operation is not possible in a rapid descent, as opposed to a high speed climb.

LONG RANGE CAP STATION

The long range CAP station is normally a form of barrier CAP (BARCAP). It is defined as being beyond the normal task force early warning range, at distances of 150 to 300 miles. The altitude can either be very low to remain below enemy surveillance radars, or at about 20,000 feet for optimum use of the search capability of the radar for all-altitude coverage. The long range CAP station has the following characteristics:

Advantages

a. Provides long range one-quadrant intercepts against snoopers.

b. Provides long range one-quadrant protection against potential low flyers and descending raids, by completing the intercept before the raids descend from cruise altitude.

c. Does not conflict with friendly SAM zones.

d. Provides long range identification of raids in one quadrant.

Disadvantages

a. Requires long range picket or AEW airplane for full effectiveness.

b. Provides only single-quadrant protection for task force.

c. On-station time reduced 15 minutes for every 60 miles of distance from carrier.

In general, the long range CAP station provides the task force with very long quadrant intercepts against snoopers and enemy raids. Although the search capability of the radar is severely limited when compared with the F-4 radar, the possibilities of utilizing the F-8 for this type of CAP station should not be discounted. The F-8 may be used in this kind of CAP stationing even with its limited search coverage, if the expected raid approach corridor is narrow. In some instances, an F-8 can be stationed with an F-4, the latter acting as a controlling and search agency.

A typical mission would be a climb out and descent to a CAP station at 175 miles. The combat fuel package available on station would be 4,000 pounds, sufficient for at least one subsonic intercept, or a total of 90 minutes loiter, at 20,000 feet. Total cycle time would approximate 2 hours for the loiter mission and 80 minutes if subsonic combat is required.

PART 2 — AIR-TO-GROUND WEAPONS DELIVERY

INTRODUCTION

In the air-to-ground role, the F-8 can be used in coordinated Air Wing strike missions, armed reconnaissance and close air support of ground forces. The F-8, configured with wing pylons and bomb racks, has the capability to carry and deliver a variety of bombs, rockets and 20mm ammunition.

EMPLOYMENT

Reconfiguration time (attack to fighter/fighter to attack) will be from four to six hours. This time will vary depending on aircraft spot on the ship, availability of equipment, weather conditions, etc. The time includes electrical and armament system verification checks.

If aircraft resources and tactical considerations permit, a selected number of aircraft should remain air-to-ground or attack configured while a selected number remain fighter configured. This method will improve system reliability and eliminate time lost in reconfiguring aircraft.

EXTERNAL ARMAMENT LIMITATIONS

CAUTION

With full fuel and ammunition load, the maximum gross takeoff weight of 34,000 pounds can be exceeded with some combinations of external stores. Refer to AN 01-1B-40 Handbook of Weight and Balance for specific aircraft weight and to figure 2–14 for individual store weights. If the total weight exceeds 34,000 pounds, wing fuel may be removed to reduce the gross weight. Do not remove more than 3,000 pounds of wing fuel or the center of gravity will move forward of the takeoff limit.

Only the external armament stores listed in this manual may be carried and released singly or in combination to the limits shown. When carrying stores in combination, the more restrictive limits apply. All stores are cleared for catapult and arrested landings unless otherwise noted. Operating limitations for the basic aircraft apply with fuselage pylons and stores, and wing pylons and bomb racks installed. Operating limitations for the attack configured aircraft apply when carrying wing stores. Empty rocket packs and empty multiple bomb racks are considered to be wing stores. External armament combinations appear in Section II with weights useful in planning attack missions.

CARRIER OPERATING LIMITATIONS

Carrier operations are not permitted at gross weights in excess of 30,000 pounds with asymmetrical external wing stores loadings.

Catapult launches with an asymmetrical external wing loading imbalance in excess of 2,000 pounds are not permitted.

Arrested landings with external stores should be avoided whenever possible. However, if necessary, arrested landings with nonexpendable/nonjettisonable stores may be conducted within current gross weight limitations providing external wing stores loading per station and asymmetrical wing stores loading imbalance, if any, do not exceed 2,000 pounds.

Barricade engagements are permitted. Stores will not interfere with barricade engagement but may tear loose and present a hazard to flight deck personnel.

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